THE ROYAL OBSERVATORY AT 350: AN UNTOLD HISTORY

BBC

#243 AUGUST 2025

Sky at Night

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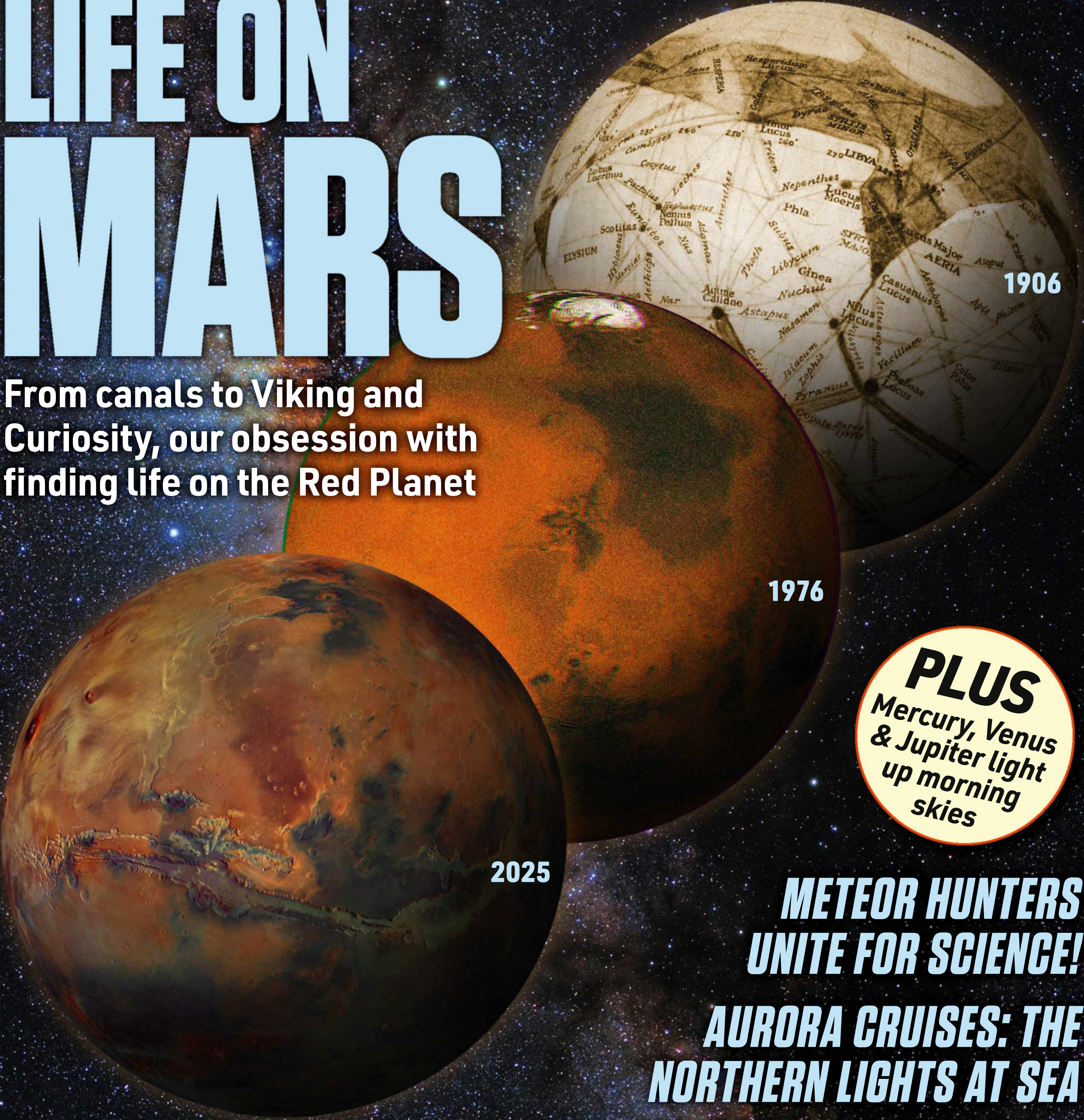

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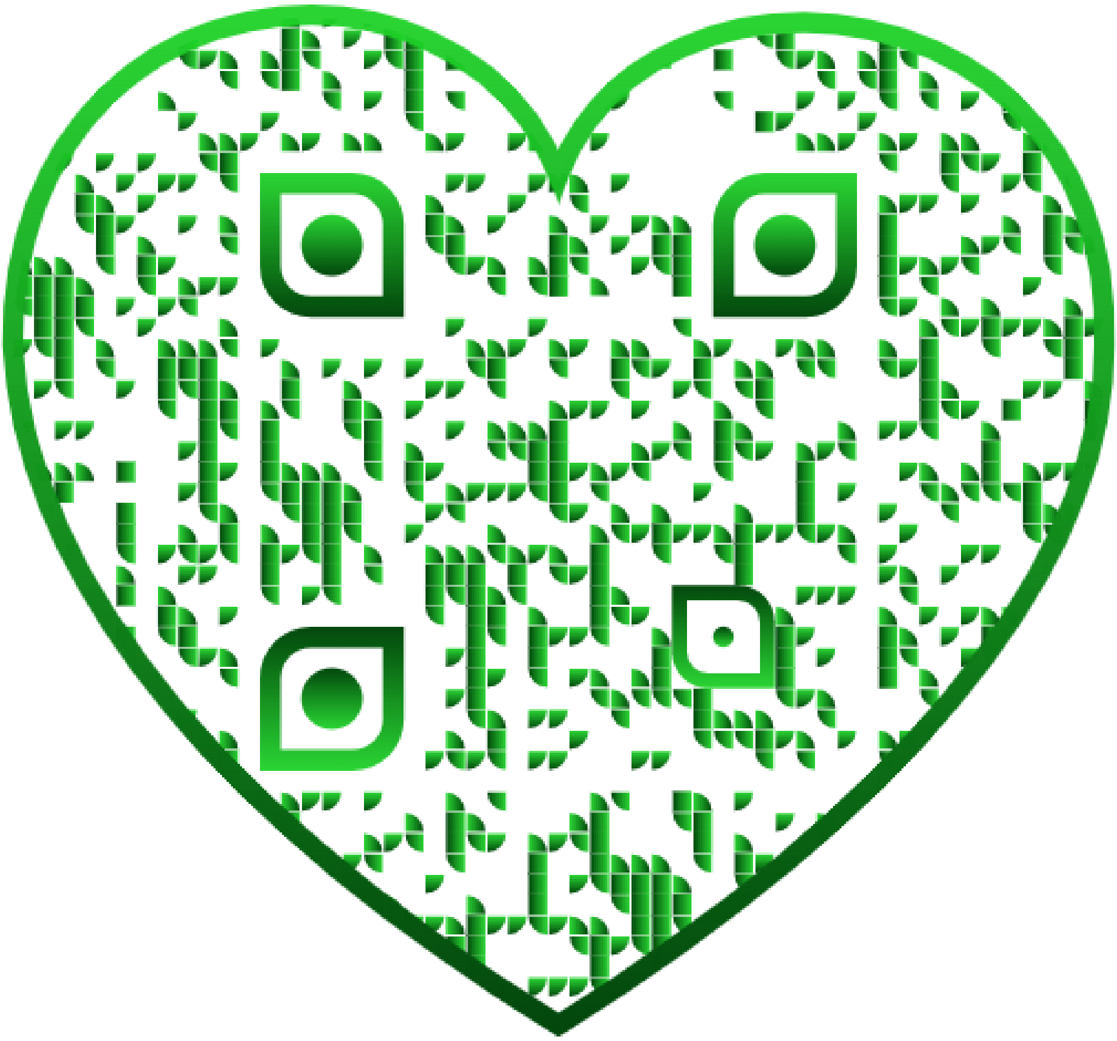

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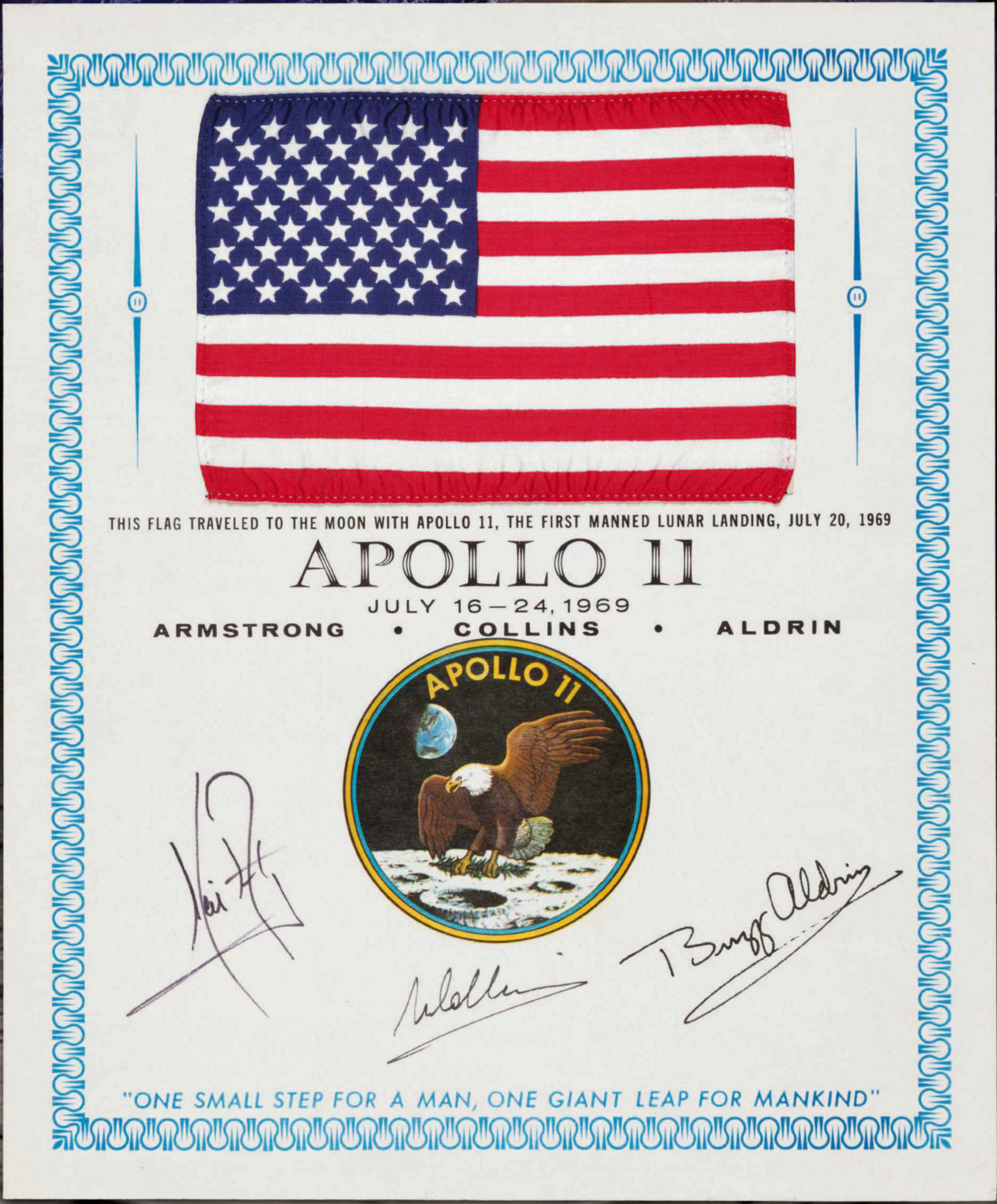

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Welcome

Is there life on Mars? We've been asking for centuries

The prospect of life on our neighbouring planet, Mars, has long held us in its sway. Across the eras, the idea has gripped us in different ways: from the utopian visions of an enlightened Martian society in the 19th century, to the warmongering aliens of mid-20th-century pulp-fiction comics. Today, science may have advanced, but, as Ben Evans considers in his fascinating feature on **page 34**, we are no less enthralled by the chance that life exists – or could have once existed – on the Red Planet.

I wonder if in ages past, while observing the stars above London, the thought of Martian society ever crossed the minds of the astronomers at the Royal Observatory Greenwich? This month, 350 years will have passed since the foundation stone of this grand institution was laid by the first Astronomer Royal, John Flamsteed. To mark the anniversary, author and historian Emily Winterburn visited Greenwich and the line marking the world's Prime Meridian, and uncovered the stories of the unsung figures who have shaped its remarkable history. Find her alternative take on **page 28**.

We celebrate another anniversary this month, as *The Sky at Night* presenter Chris Lintott marks 25 years since his first appearance on the show. On **page 18**, he looks back on his first on-screen outing with Sir Patrick Moore, as well as the scientific discoveries and standout moments the team has covered in his time. From all of us on the magazine team, congratulations Chris!

Chris Bramley, Editor

PS Our next issue goes on sale on Tuesday 12 August.

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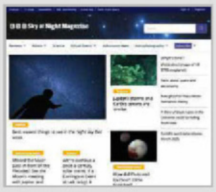
Sky at Night – lots of ways to enjoy the night sky...

The Sky at Night

Television

Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18



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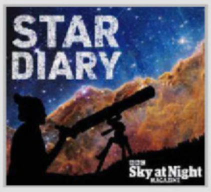

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Discover the best things to see in the night sky every month with our Star Diary podcast

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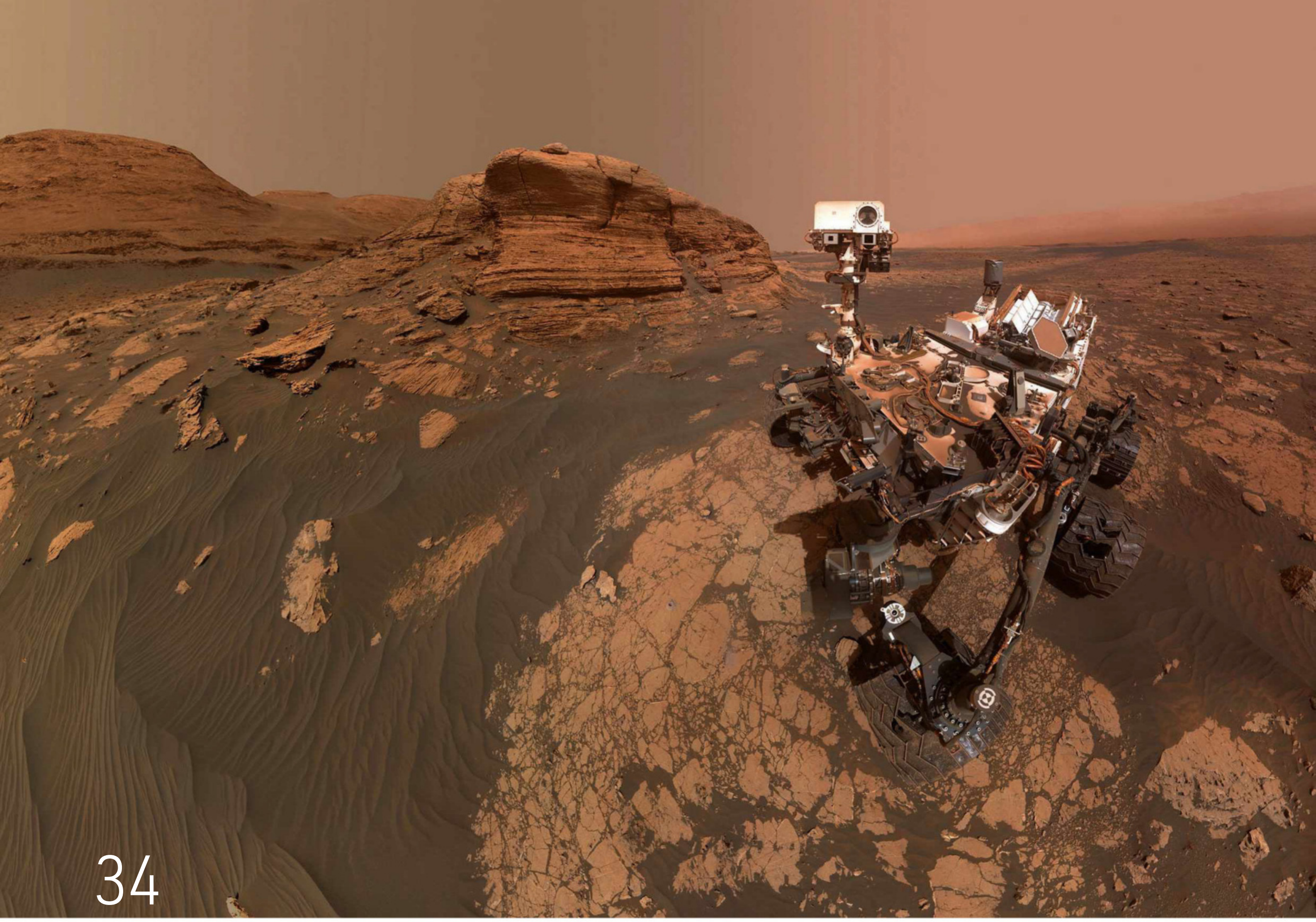

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The Sky Guide

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New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**

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This month's contributors

Emily Winterburn

Astronomy historian

"It's been fascinating finding out about the 350-year history of the Royal Observatory Greenwich and the people who worked there." **Emily uncovers the unsung heroes that made the Observatory on page 28**

Mark Hardaker

Astronomy communicator

"From its bright star Antares and its mythological origins, to its deep-sky treasure trove, Scorpius is well worth seeking out this month." **Mark is your guide to the stars with a sting, page 40**

Mark McIntyre

Meteor expert

"It's never been easier for amateurs to contribute to meteor science. We'll tell you how you can find meteorites, help discover new showers, keep astronauts safe, and more." **Get into meteor science with Mark on page 66**

FREE BONUS CONTENT

Find it at **www.skyatnightmagazine.com/bonus-content**

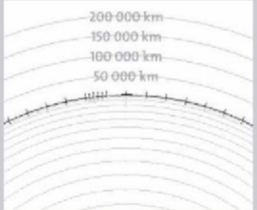
AUGUST HIGHLIGHTS

Interview: our Galaxy's near-miss

Astronomer Alis Deason reveals why our Milky Way may not collide with the Andromeda Galaxy after all.

Your best images of the Universe

Our extended gallery featuring the best astro images sent to us by *BBC Sky at Night Magazine* readers.



Track and record sunpots safely

Download a solar ruler to help you measure sunspots regions lying close to the solar limb. See page 74 for details.

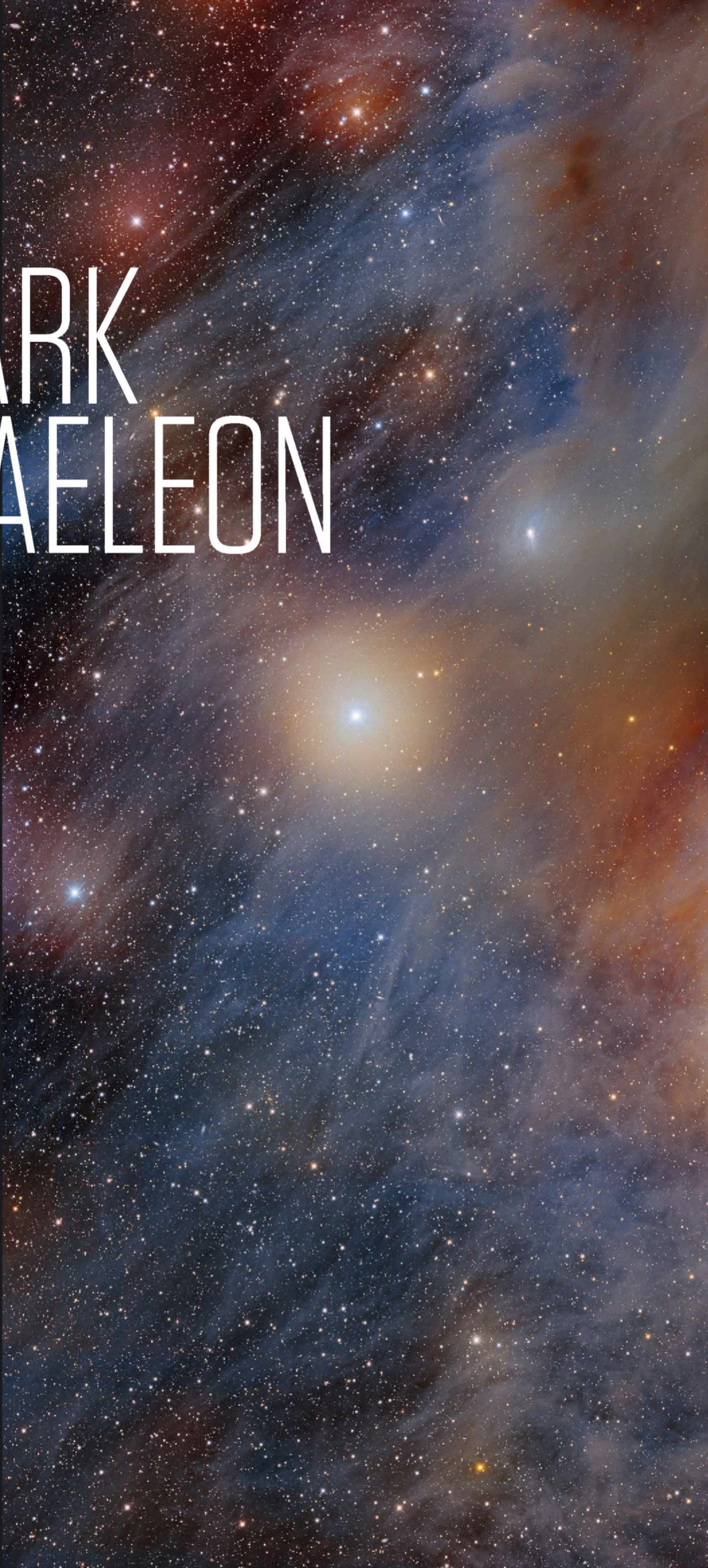
The Virtual Planetarium

Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

THE DARK CHAMAELEON

A closer look at a star factory cloaked in shadow on Earth's doorstep

VICTOR M BLANCO 4-METER TELESCOPE, 10 JUNE 2025



The Chamaeleon I dark cloud is one of the closest star-forming regions to Earth. It sits at the surface of the Local Bubble – the sparsely populated region of the Milky Way's Orion arm through which our Solar System has been travelling for the past five to 10 million years – and, together with the Chamaeleon II and Chamaeleon III dark clouds, forms part of a larger structure, the Chamaeleon Complex. As well as containing three reflection nebulae, the region is thought to be home to 200–300 stars with a median age of just one or two million years.

Astronomers say the birth of our own Sun and the Solar System planets can be traced back to huge clouds of gas and dust not unlike those seen in this image.

CTIO/NOIRLAB/DOE/NSF/AURA/IMAGE PROCESSING/T.A. RECTOR (UNIVERSITY OF ALASKA ANCHORAGE/NSF NOIRLAB) M. ZAMANI & D. DE MARTIN (NSF NOIRLAB)

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Explore a gallery of these and more stunning space images

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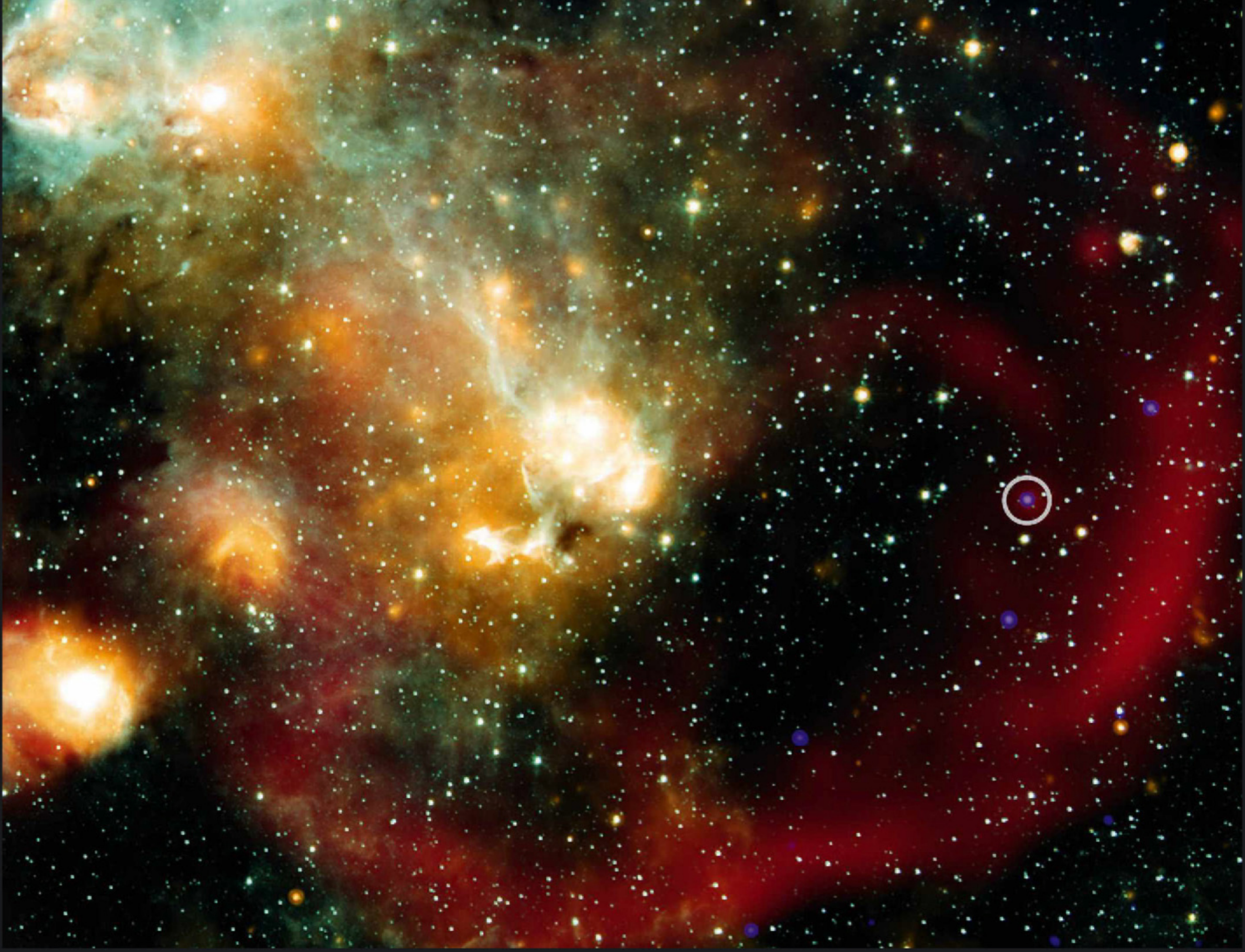


△ Odd one out

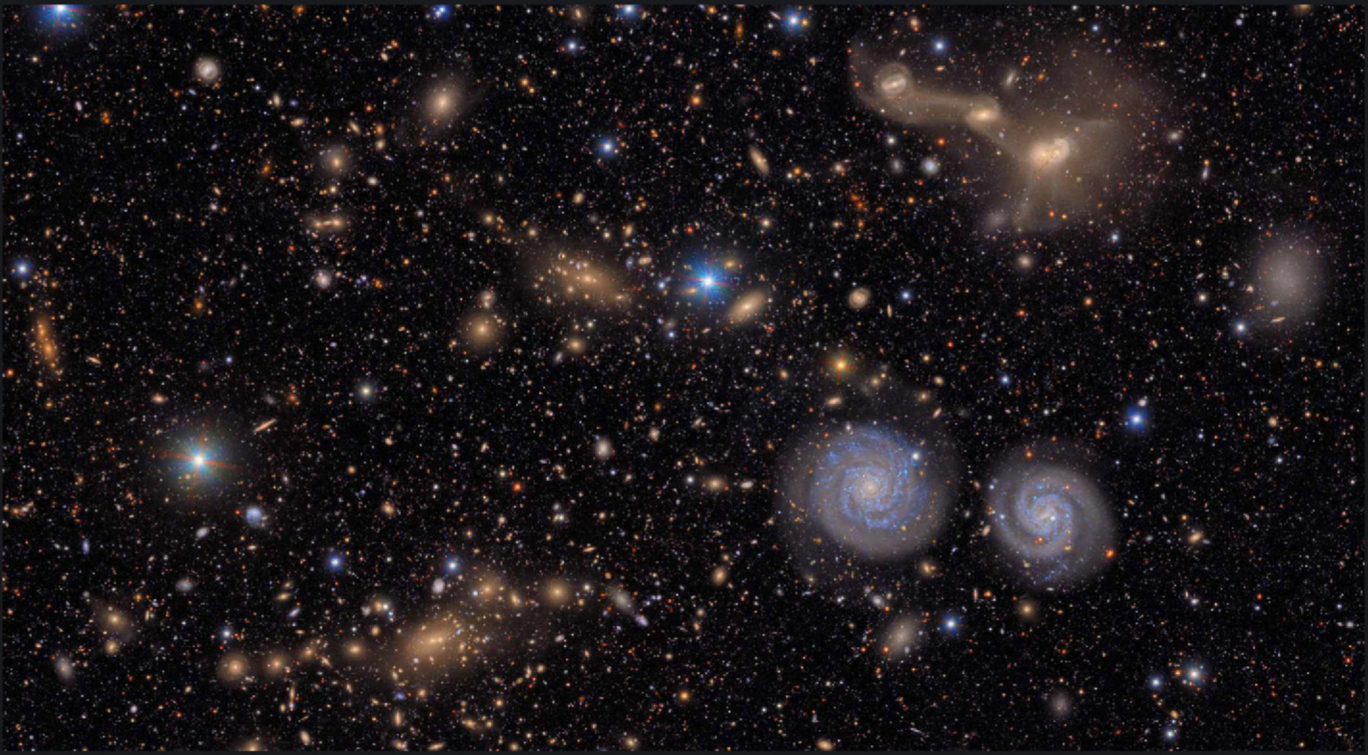
CHANDRA X-RAY OBSERVATORY, LOFAR, SKA PATHFINDER, SPITZER SPACE TELESCOPE, 28 MAY 2025

This image, combining X-ray, radio and infrared data from several scopes, shows the southern constellation Scutum. The circled purple dot is ASKAP J1832, a star whose intensity varies in a regular pattern at these wavelengths. Astronomers are still unsure exactly what type of star it is.

▽ Rubin's cosmic curtain raise

VERA C RUBIN OBSERVATORY, 23 JUNE 2025

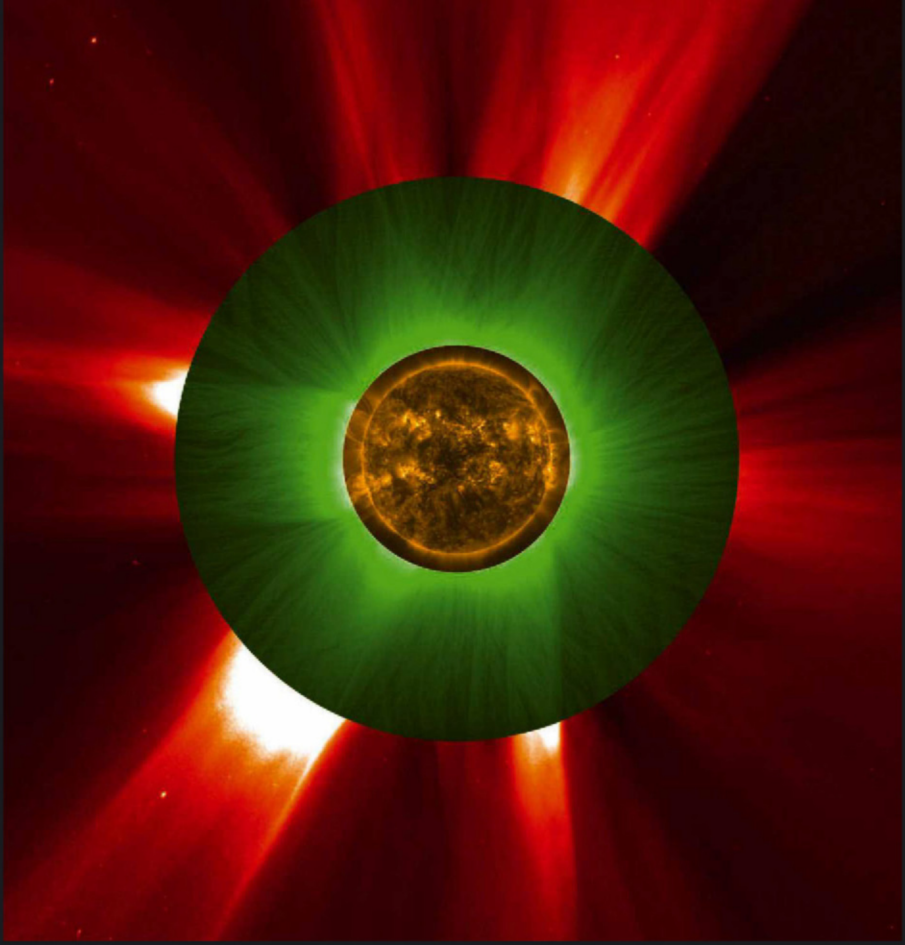
Three merging galaxies (top right), two crisp spirals (centre right) and other deep-sky jewels shine in this view of the Virgo Cluster – one of the first images from the world's largest camera, housed at the Rubin Observatory. The facility is tasked with solving some of the biggest mysteries in science, including the structure of our Galaxy and the nature of the invisible dark Universe.



An engineered eclipse ▷

PROBA-2, PROBA-3, SOHO, 16 JUNE 2025

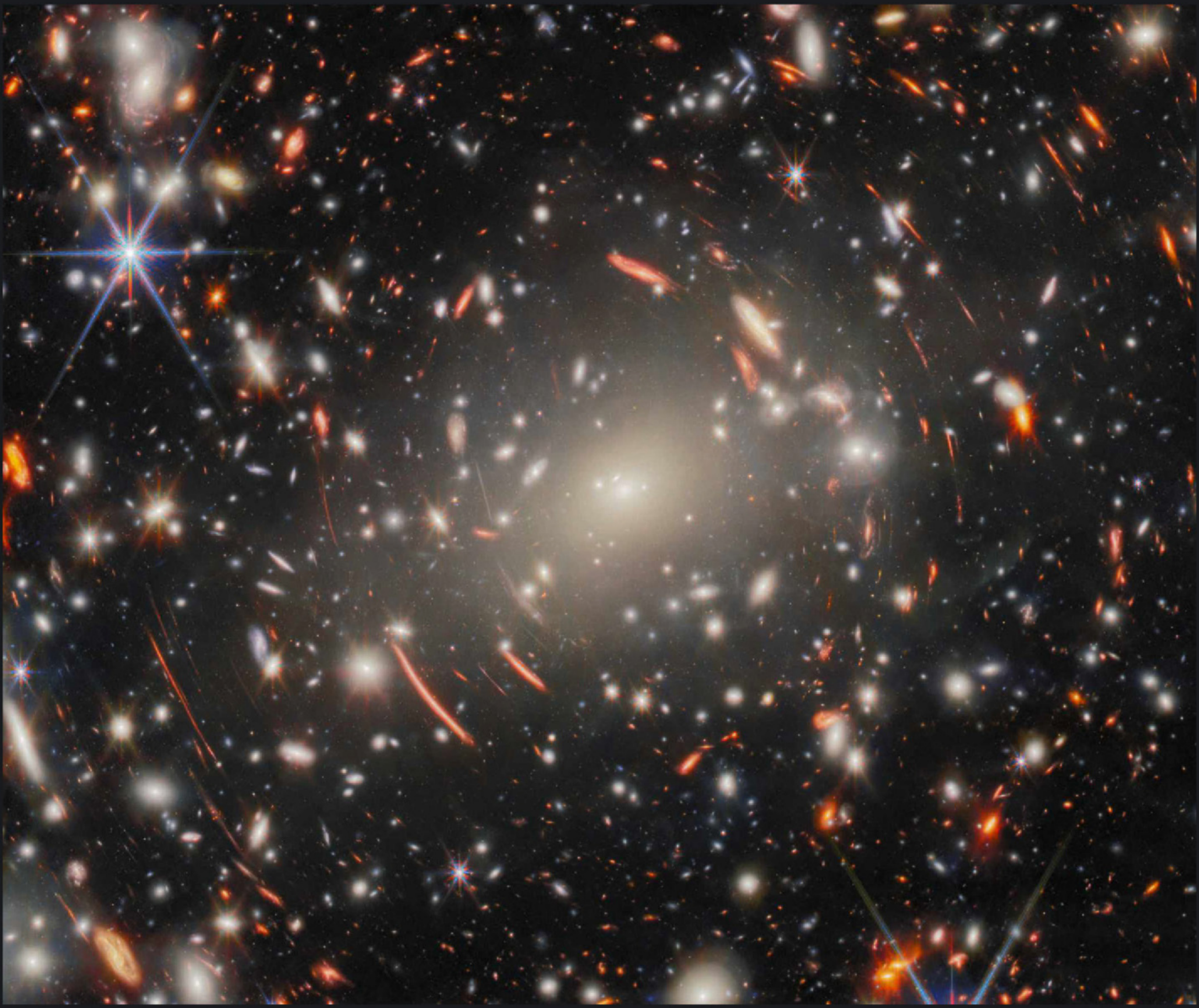
ESA's Proba-3 mission consists of two spacecraft flying just 150 metres (492ft) apart, with a 1.4-metre (4.6ft) disc carried by one spacecraft blocking the Sun so that the other can capture a clear view of the corona, its outer atmosphere. This image was created using data from Proba-3, the Proba-2 satellite and ESA's Solar and Heliospheric Observatory.



▽ Galactic light warp

JAMES WEBB SPACE TELESCOPE, 27 MAY 2025

Abell S1063 is an immense galaxy cluster some 4.5 billion lightyears away in the southern constellation of Grus, the Crane. The orange-reddish arcs encircling it are light from much older and more distant galaxies that has warped around the cluster – an effect known as 'gravitational lensing'.



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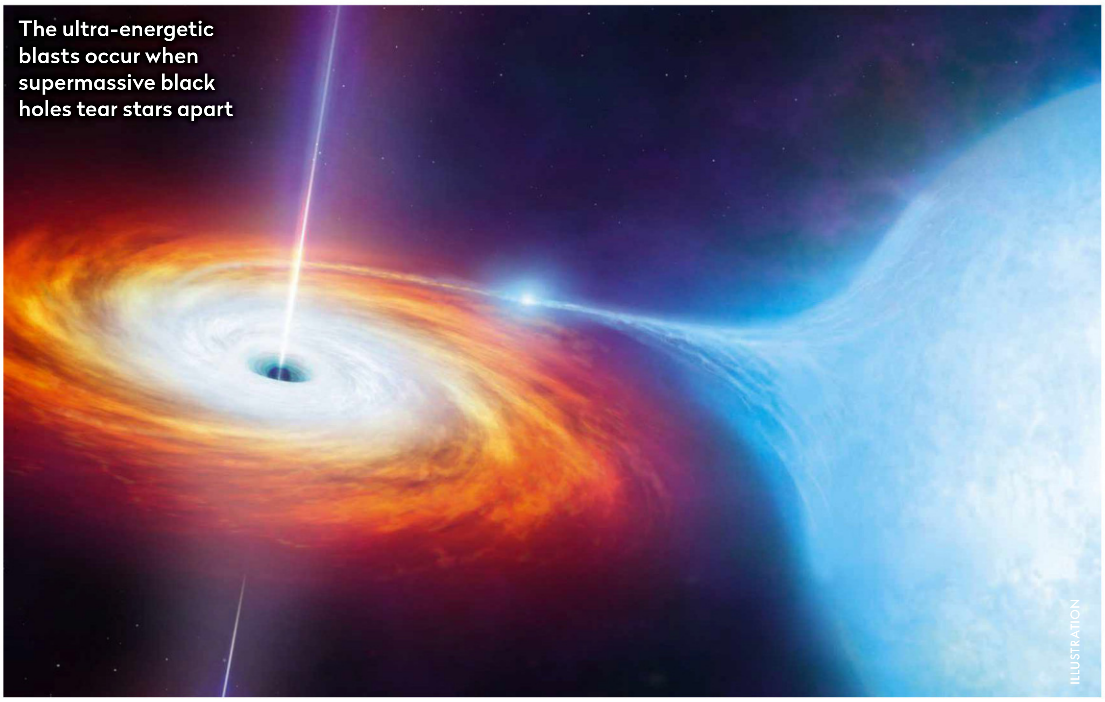
The latest astronomy and space news, written by Anita Chandran

BULLETIN



The ultra-energetic blasts occur when supermassive black holes tear stars apart

New bangs are the largest since the Big One

Astronomers spot biggest space explosions ever discovered

Scientists from the University of Hawaii's Institute for Astronomy (IfA) have discovered the most energetic cosmic explosions since the Big Bang. Extreme nuclear transients (ENTs) occur when massive stars several times larger than our Sun are torn apart by supermassive black holes.

ENTs shine with intense luminosity, much brighter than supernovae, which originate from the violent death of massive stars. One ENT observed by the team at IfA emitted over 25 times more energy than the most energetic supernovae known, radiating the energy of around 100 Suns in a single year.

"We've observed stars getting ripped apart as tidal disruption events for over a decade, but these ENTs are different beasts, reaching brightnesses nearly 10 times more than what we typically see," said Jason Hinkle, the researcher at IfA who led the study. The vast amount of energy released by these explosions can be visible over huge distances.

Hinkle first uncovered ENTs when searching for long-lived flares coming from galactic centres. The intense outbursts are examples of transients: astrophysical events that change brightness over a relatively short time. In his search of data from ESA's Gaia mission, he discovered two particularly unusual events that brightened over a timescale longer than typical transients, and without their other characteristics. The researchers determined that ENTs could not be simple supernovae because they release far more energy. Instead, their unique characteristics suggest the involvement of a supermassive black hole.

"ENTs provide a valuable new tool for studying massive black holes in distant galaxies," adds Benjamin Shappee, associate professor at IfA and the study's co-author. "By observing these prolonged flares, we gain insights into black hole growth when the Universe was half its current age, when galaxies were happening places – forming stars and feeding their supermassive black holes 10 times more vigorously than they do today."

ENTs remain rare, occurring 10 million times less frequently than supernovae. As such, their detection is challenging. Future observatories like the Vera C Rubin Observatory and NASA's Roman Space Telescope will aid in the search for these cosmic flashbangs.

www.ifa.hawaii.edu

MARK GARLICK/SCIENCE PHOTO LIBRARY/GETTY, ELLIS BOGAT, ISPACE

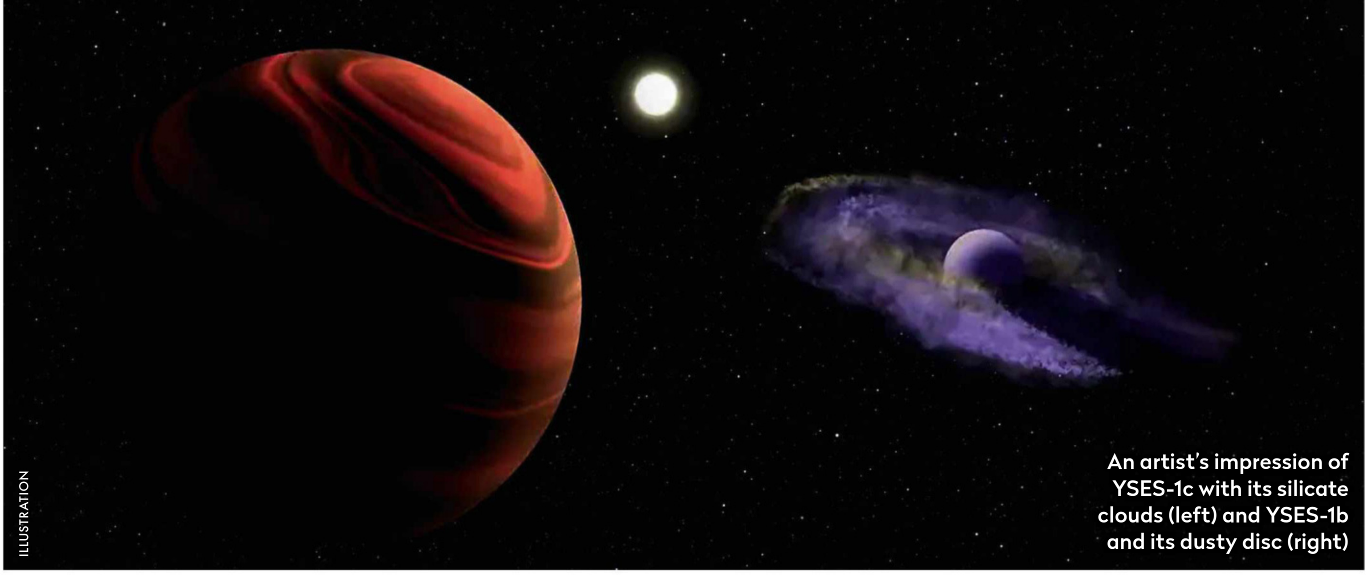
Comment

by Chris Lintott

To follow up on discoveries like these, you need a telescope capable of monitoring the whole sky, one that can ferret out unusual events. We're about to get such an instrument, with the Vera C Rubin Observatory starting operations around the time you read this.

With a mirror as large as some of the largest telescopes on Earth, the world's largest camera and an ability to scan the whole sky every three nights, Rubin will help spot the 'weird' in the Universe. Producing 30 terabytes of data a night and issuing roughly 10 million alerts, it will revolutionise how astronomical research is conducted. We're about to be surprised by more ENTs – and plenty of other novelties besides.

Chris Lintott co-presents *The Sky at Night*



An artist's impression of YSES-1c with its silicate clouds (left) and YSES-1b and its dusty disc (right)

JWST spies two eccentric exoplanets

Sand-like clouds and a possible moon-forming disc spotted around distant worlds

Astronomers have detected two puzzling exoplanets orbiting a distant, Sun-like star known as YSES-1. The observations revealed sand-like silicate clouds around one and an unexpected disc around the other.

The planets, YSES-1c and YSES-1b, are several times larger than Jupiter and are in a distant orbit from their host star. Because they are relatively young, around 16.7 million years old, they are still hot and produce thermal infrared radiation. To spot them, an international team used JWST's infrared-sensitive instruments to obtain spectra and determine the composition of their atmospheres.

"When we looked at the smaller, farther-out companion, YSES-1c, we found the tell-tale signature of silicate clouds," says Dr Evert Nasedkin, a member of the team based at Trinity College Dublin. "This is the strongest silicate absorption feature observed in an exoplanet yet."

The disc around the inner planet, YSES-1b, was also surprising. The disc is thought to feed material onto the planet and serve as a nursery for moons similar to Jupiter's moons. Only three such discs have been discovered to date, around objects far younger than YSES-1b, leaving astronomers searching for answers.

"The YSES-1 system's planets are also too widely separated to be explained through current formation theories, so the additional discoveries of distinct silicate clouds around YSES-1c and hot dusty material around YSES-1b lead to more mysteries and complexities for determining how planets form and evolve," says Dr Kielan Hoch, Giacconi Fellow at the Space Telescope Science Institute.
www.stsci.edu

Another Moon crash for Japanese lunar lander

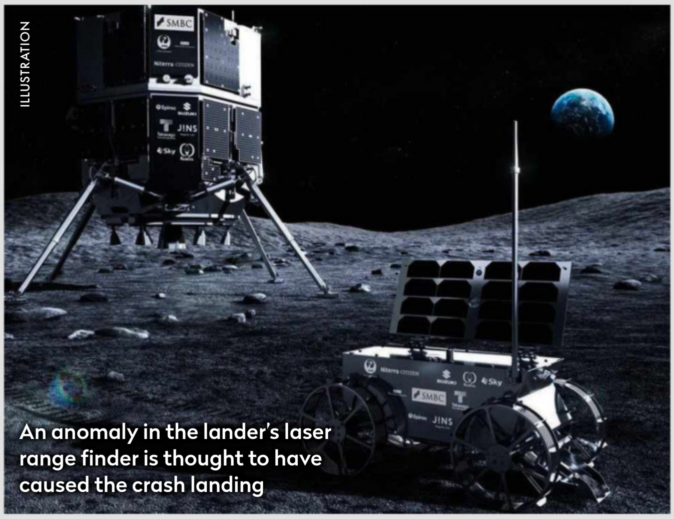
The spacecraft Resilience failed to touch down on the Moon after a sensor malfunction

The Hakuto-R Mission 2, named Resilience, has failed to land near the centre of the Moon's Mare Frigoris (Sea of Cold) after its laser range-finder malfunctioned during descent. The failure marks another blow for Japanese private robotic exploration company ispace, whose earlier mission to the Moon also crash landed in 2023.

Resilience launched in January from Kennedy Space Centre, Florida, aboard a SpaceX Falcon 9 rocket. It travelled for four months before entering a lunar orbit on 7 May. The Japanese firm lost communications with the craft as it began its descent phase.

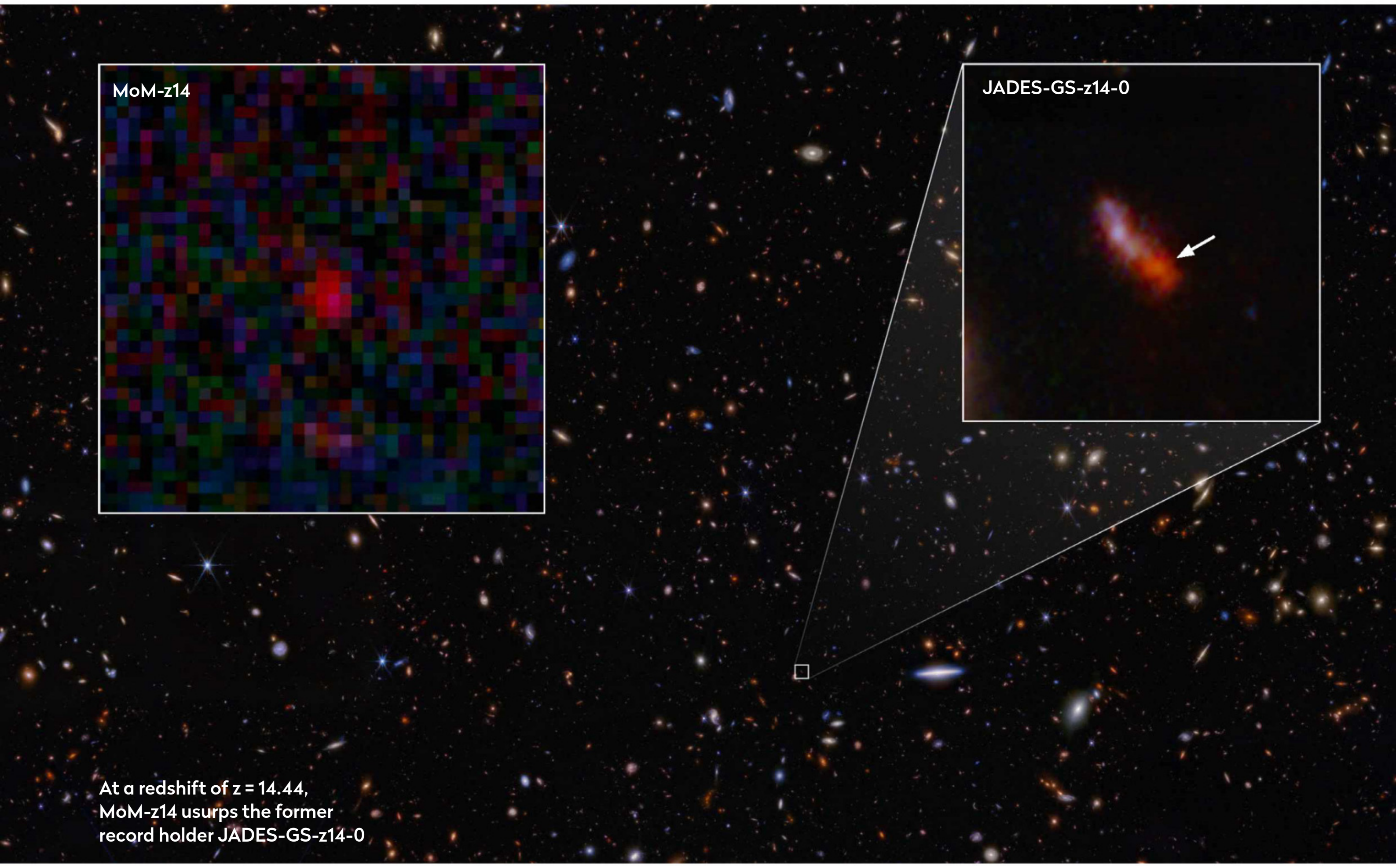
"ispace will not let this be a setback. We will not stop here, but as determined pioneers of the cislunar economy, we will strive to regain the trust of all stakeholders and embark on the next mission," said ispace founder Takeshi Hakamada.

The firm's analysis of flight data concluded that the spacecraft's range-finding equipment experienced a delay, meaning that it couldn't accurately measure its distance to the lunar surface during descent. It was therefore unable to decelerate in time to avoid a hard landing.



An anomaly in the lander's laser range finder is thought to have caused the crash landing

The mission was planned to have operated for around two weeks and carried a number of payloads, worth around $16 million, including a Swedish artwork called The Moonhouse, intended to be placed at a 'significant' site on the Moon. Its crash now casts doubts on the company's future intentions for Moon habitation, including its goal of establishing a lunar colony by the 2040s.
www.ispace-inc.com



At a redshift of z = 14.44, MoM-z14 usurps the former record holder JADES-GS-z14-0

JWST uncovers most distant galaxy so far

Galaxy MoM-z14 traces back to just 280 million years after the Big Bang

One of the JWST's superpowers is its ability to investigate the cosmic dawn, the first few hundred million years after the Big Bang. The telescope has once again lived up to its reputation, spotting light from a galaxy which existed only 280 million years after the Big Bang, the most distant ever detected. Known as MoM-z14, it displaces the previous record holder, JADES-GS-z14-0, which existed 300 million years after the Big Bang.

When looking for these galaxies, JWST investigates objects with high redshift. Redshift, often denoted by z, is where the wavelength of light becomes stretched as it travels to us through expanding space. The redder the light, the higher the redshift and the more distant the object. You may have heard of the phenomenon in the case of sound; it's similar to how an ambulance siren drops in pitch as the vehicle speeds away from you.

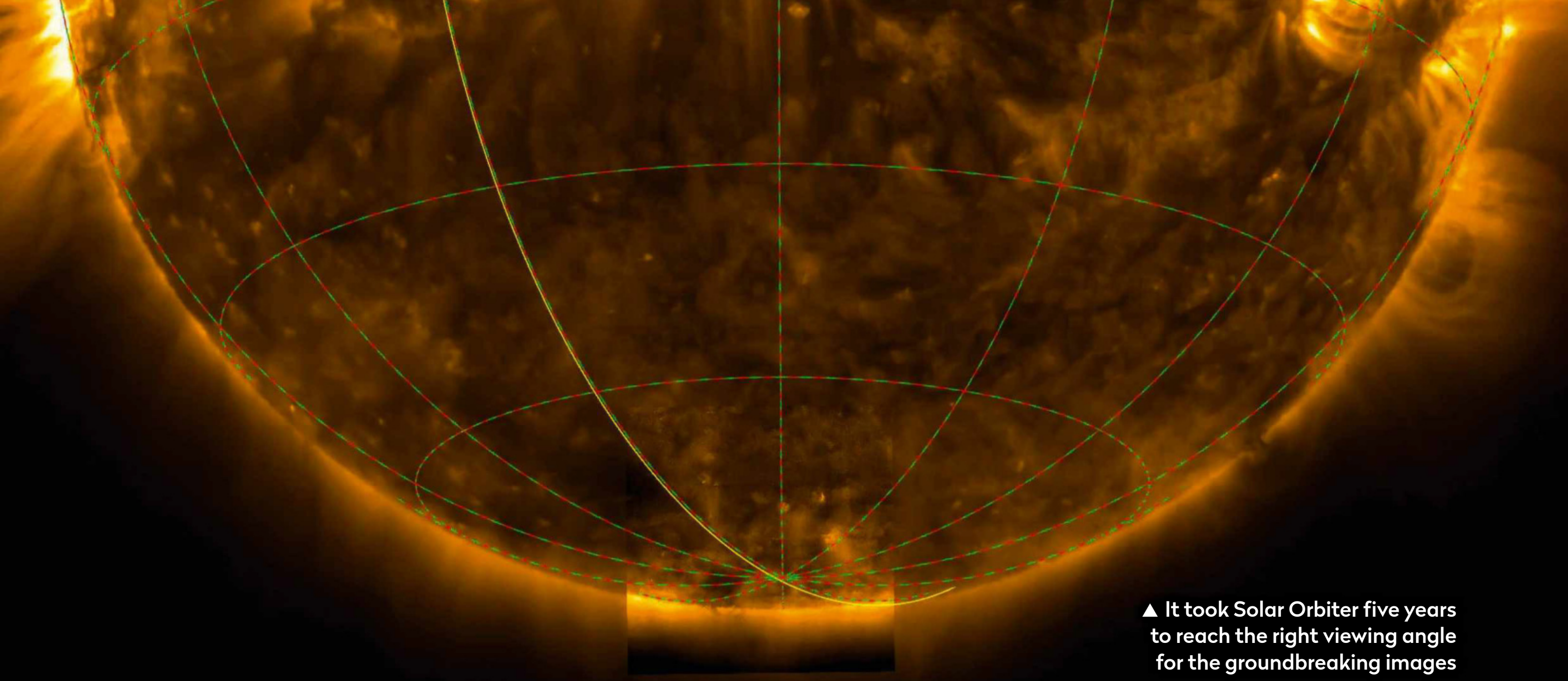
By detecting redshifted light with JWST's infrared instruments, astronomers can determine the distance and composition of early galaxies. The newly discovered galaxy, MoM-z14, has a redshift of just over 14. While the detection of such a distant object is impressive, what's more surprising is the existence of these galaxies themselves.

"JWST has revealed a stunning population of bright galaxies at surprisingly early epochs, $z > 10$, where few such sources were expected," the authors note in their early pre-publication study. At this stage in the Universe's history, astronomers had not anticipated detecting any galaxies using JWST. Instead, they have found more than 100 relatively bright galaxies from the period just after the cosmic dawn.

JWST observations have also identified the presence of heavier elements, such as carbon and nitrogen, in MoM-z14. This suggests that even earlier, less chemically evolved galaxies exist. These galaxies, composed solely of the light elements hydrogen and helium, are still waiting to be discovered.

The researchers comment: "JWST appears poised to drive a series of great expansions of the cosmic frontier – previously unimaginable redshifts, approaching the era of the very first stars, no longer seem far away."
www.webbtelescope.org

MOM-Z14: ROHAN P. NAIDU ET AL (2025)/NASA/JWST, NASA/ESA/CSA/STSCI/BRANT ROBERTSON (UC SANTA CRUZ) BEN JOHNSON (CFA) SANDRO TACCHELLA (CAMBRIDGE) PHILL CARGILE (CFA), ESA & NASA/ SOLAR ORBITER/EUI TEAM/D. BERGHMANS (ROB), ESA & NASA/SOLAR ORBITER/PHI/EUI AND SPICE TEAMS



▲ It took Solar Orbiter five years to reach the right viewing angle for the groundbreaking images

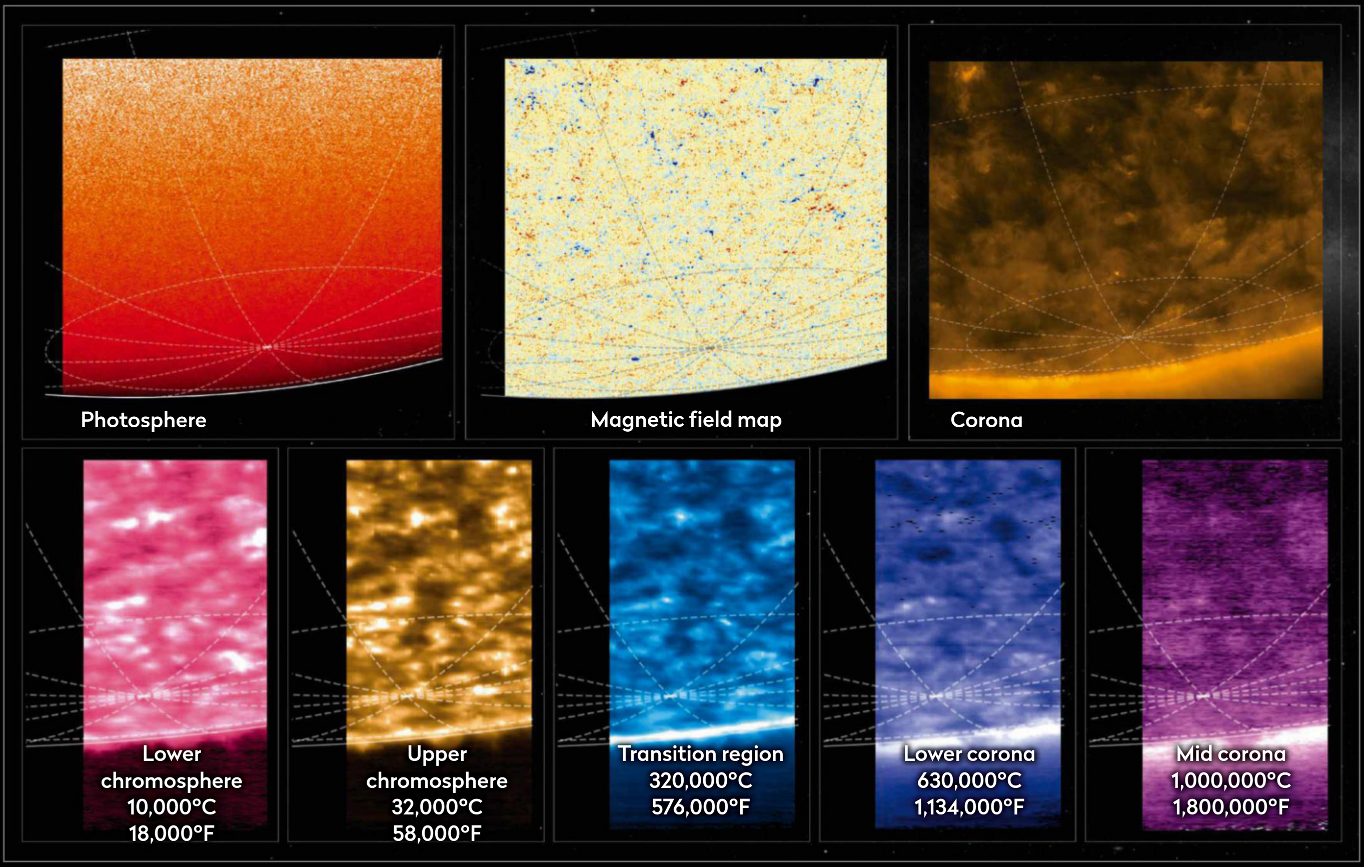
Solar orbiter snaps Sun's south pole

European Space Agency probe beams back first images and video of the Sun from a never-before-seen angle

Until now, every image of our Sun has been taken from around its equator. Now, ESA's Solar Orbiter spacecraft has pulled off a solar first and imaged the Sun from its south pole. These are humanity's first-ever views of our star from this angle.

"The Sun is our nearest star, giver of life and potential disruptor of modern space and ground power systems, so it is imperative that we understand how it works and learn to predict its behaviour. These new, unique views from our Solar Orbiter mission are the beginning of a new era of solar science," says Professor Carole Mundell, ESA's director of science.

Analysing the data taken from all three of Solar Orbiter's imaging instruments will tell scientists about material moving in the Sun's outer layers. As well as revealing unexpected behaviour, like turbulent whorls of gas around the Sun's poles, the new observations will be key to understanding the Sun's magnetic fields and its 11-year cycle. **www.esa.int**


Photosphere
Magnetic field map
Corona
Lower chromosphere 10,000°C 18,000°F
Upper chromosphere 32,000°C 58,000°F
Transition region 320,000°C 576,000°F
Lower corona 630,000°C 1,134,000°F
Mid corona 1,000,000°C 1,800,000°F

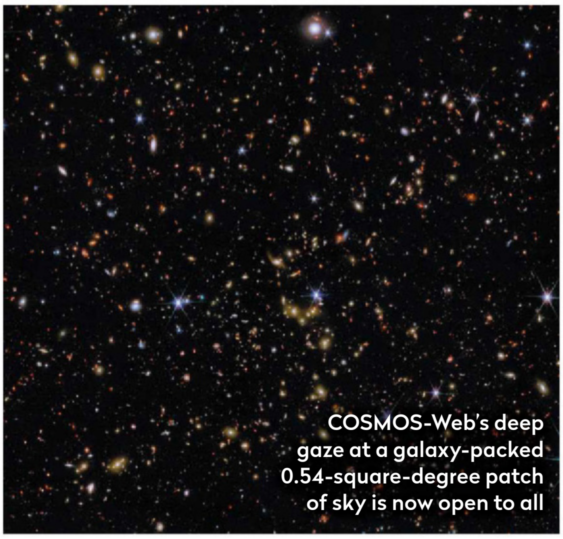
▲ As Solar Orbiter imaged high above the pole in different wavelengths, it revealed (top row, from left): iron particles; the surface magnetic field; outer atmosphere (corona), and (bottom row): layers above the surface, from the cooler chromosphere to the million-degree corona

Mega-map offers a new window on the Universe

Interactive survey features 800,000 galaxies across all of cosmic time

The Cosmic Evolution Survey (COSMOS) has released an interactive version of the largest-ever map of the Universe. In a triumph for democratic science, the multinational collaboration took data from the JWST to compile a catalogue of over 800,000 galaxies spanning all of cosmic time, corresponding to over 255 hours of astronomical observation.

The map, a composite image across 0.54 square degrees of sky, reaches back into the early Universe, with data going as far back as 13.5 billion years, around 98 per cent of all cosmic time. The goal was to reconstruct the deep field of space, examining the composition of the far, faint Universe on an unprecedented scale.


COSMOS-Web's deep gaze at a galaxy-packed 0.54-square-degree patch of sky is now open to all

Caitlin Casey, professor at the University of California Santa Barbara and one of the leaders of the COSMOS-Web project, compares it to the iconic image captured by the Hubble Space Telescope in 2004: "If you had a printout of the Hubble Ultra Deep Field on a standard [A4] piece of paper, our image would be slightly larger than a 13ft by 13ft mural, at the same depth. So it's really strikingly large."

Although the data has been available to researchers for some time, it previously required a supercomputer to interpret, which made it difficult to access. COSMOS's aim was to make the information more usable for a general audience.

"A big part of this project is the democratisation of science and making tools and data from the best telescopes accessible to the broader community," Casey continues.

The map also has significant scientific implications. Not only can astronomers now see data from galaxies that existed in the period just after the Big Bang, they can also place them in context, revealing how matter is organised in dense regions and empty voids. This structure, and how it forms and evolves, holds clues to the nature of the Universe.

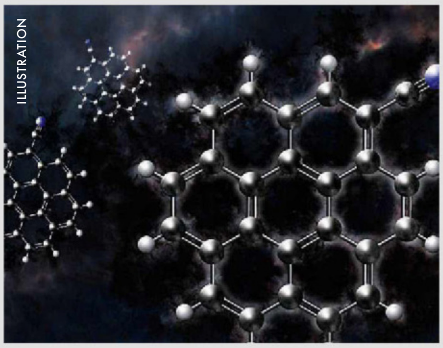
You can read more about COSMOS-Web at **cosmos.astro.caltech.edu** and access the interactive map at **cosmos2025.iap.fr/fitsmap.html**.

Aromatic compound in deep space is biggest yet

Astronomers uncover a large hydrocarbon molecule in a cold, dark molecular cloud

Deep in the cold, dark recesses of a lightyears-wide nebula known as the Taurus molecular cloud (TMC-1), astronomers have discovered cyanocoronene, the largest polycyclic aromatic hydrocarbon (PAH) ever detected in space.

PAHs have a bad reputation on Earth, as they arise from the incomplete combustion of organic matter, such as in tobacco smoke or exhaust fumes, with harmful implications to health. In the broader Universe, however, they are thought to lock away carbon and play a key role in the chemistry that leads to the formation of stars and planets.



▲ **The potential life-building molecule may be more common than previously thought**

The study recreated cyanocoronene in the lab to determine its unique chemical signature. With this in hand, scientists tracked observational data from TMC-1, finding clear signs of the large PAH. Containing 24 carbon atoms, it is the largest individual PAH to have been detected in interstellar space.

The cyanocoronene was in similar amounts to smaller PAHs found before, hinting that such molecules may be more common in space than previously thought. They could act as stable reservoirs of carbon, seeding new planetary systems with the ingredients for life. Researchers now aim to find even larger PAHs and to understand how they survive the extremes of space.

"Each new detection brings us closer to understanding the origins of complex organic chemistry in the Universe – and perhaps, the origins of the building blocks of life themselves," says lead researcher Gabi Wenzel. **www.nrao.edu**

ESA/WEBB/NASA & CSA/G. GOZALIASL/A. KOEKEMOER,/M. FRANCO AND THE COSMOS-WEB TEAM, NSF/AUI/NSF NRAO/P.VOSTEEN, SCHMIDT ET AL./NJIT/NSO/AURA/NSF

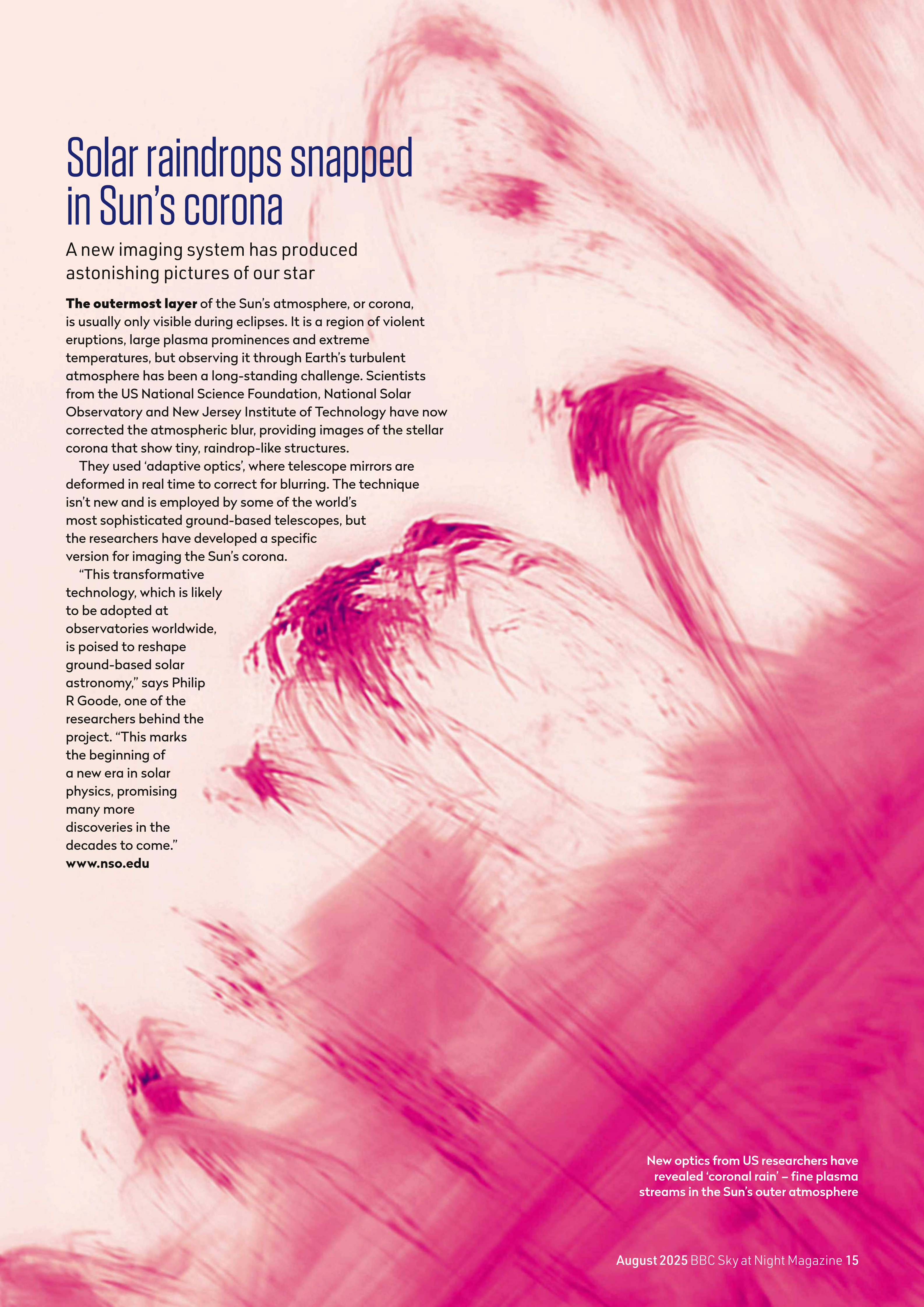
Solar raindrops snapped in Sun's corona

A new imaging system has produced astonishing pictures of our star

The outermost layer of the Sun's atmosphere, or corona, is usually only visible during eclipses. It is a region of violent eruptions, large plasma prominences and extreme temperatures, but observing it through Earth's turbulent atmosphere has been a long-standing challenge. Scientists from the US National Science Foundation, National Solar Observatory and New Jersey Institute of Technology have now corrected the atmospheric blur, providing images of the stellar corona that show tiny, raindrop-like structures.

They used 'adaptive optics', where telescope mirrors are deformed in real time to correct for blurring. The technique isn't new and is employed by some of the world's most sophisticated ground-based telescopes, but the researchers have developed a specific version for imaging the Sun's corona.

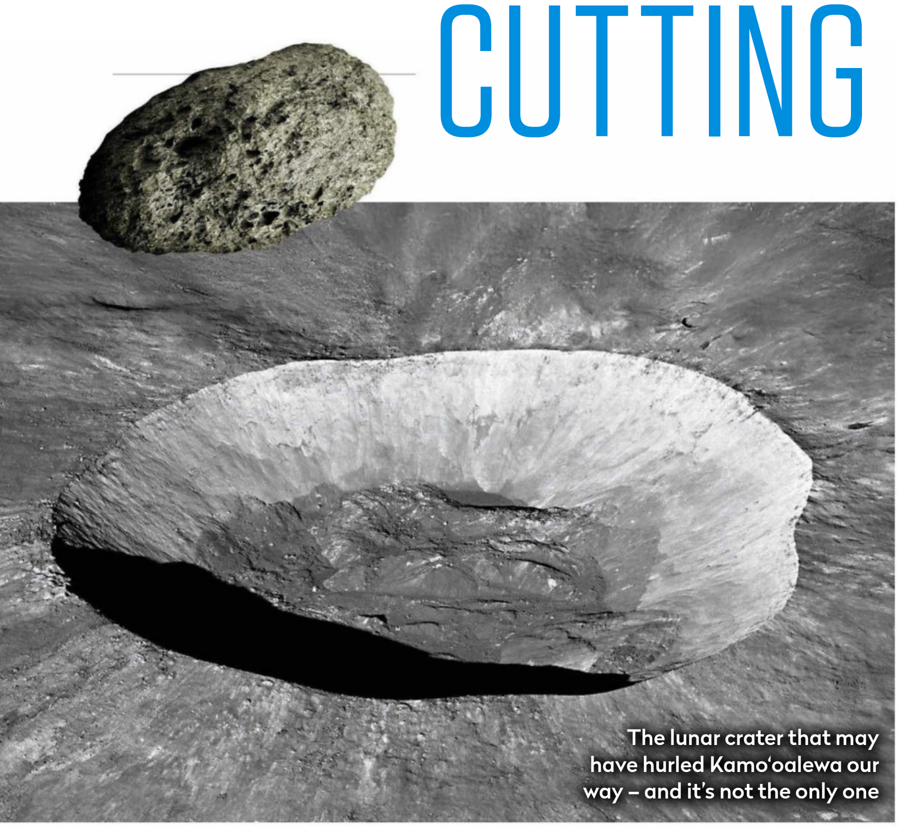
"This transformative technology, which is likely to be adopted at observatories worldwide, is poised to reshape ground-based solar astronomy," says Philip R Goode, one of the researchers behind the project. "This marks the beginning of a new era in solar physics, promising many more discoveries in the decades to come."
www.nso.edu



New optics from US researchers have revealed 'coronal rain' – fine plasma streams in the Sun's outer atmosphere

Our experts examine the hottest new research

CUTTING EDGE



The lunar crater that may have hurled Kamoʻoalewa our way – and it's not the only one

Are near-Earth rocks Moon-made?

New findings suggest that our Moon gave birth to more objects in space than we realise

The Moon has a diameter of around a quarter that of Earth and travels around our planet in a circular orbit roughly every 27 days. But Earth also possesses a number of tiny co-orbital bodies – objects orbiting the Sun and so not true satellites of Earth, but which are influenced by our planet's gravity and shadow our planet closely.

These companions fall into several categories: objects on a 'horseshoe' or 'tadpole' orbit are repeatedly accelerated and decelerated by Earth's gravity; 'quasi-satellites' follow a one-year elliptical orbit around the Sun such that they appear to be on a wide, retrograde orbit around Earth. There are four known bodies on horseshoe orbits of Earth, two in tadpole motion, five quasi-satellites, and four objects flip-flopping between quasi-satellite and horseshoe.

The orbital dynamics involved are a little complicated, but the important point is that such co-orbital objects are on very similar orbits around the Sun as Earth's. So, the question is: how did those objects get there? What's the source of these bodies that become captured – at least temporarily – as companions of Earth?

Most of them are probably near-Earth asteroids. One of the closest, most stable quasi-satellites, however, the 40-metre-wide (131ft) Kamoʻoalewa, is spectrally very similar to the lunar surface. Could this companion be a fragment of the Moon that was blasted off by a large asteroid impact and then caught as a quasi-satellite?

NASA/GODDARD/ARIZONA STATE UNIVERSITY, VENCAVOLRAB/GETTY, BAAC3NES/GETTY

Simulating lunar ejecta

Rafael Sfair, at the Sao Paulo State University, Brazil, and his colleagues, have been exploring the conditions required for lunar ejecta to develop into co-orbital bodies of Earth. This is what's known as a four-body problem, with the gravitational effects of the Sun, Earth and Moon all being important for the object's motion, and it requires precisely tracking trajectories using step-by-step computer simulations.

Sfair's team ran comprehensive simulations of 54,000 particles being ejected from across the entire globe of the Moon, with a range of ejection velocities, and tracked which became co-orbital with Earth.

They found that 3.5 per cent of their modelled ejecta particles ended up colliding with Earth, and indeed, over a tonne of lunar meteorites have been found. But 6.7 per cent of ejecta came to share a similar orbit to Earth, with over a quarter of those becoming quasi-satellites (rather than following horseshoe or tadpole orbits).

Material is most likely to become captured as a co-orbital object if it is ejected from the trailing (western) side of the Moon and near the equator. A previous study had suggested that Kamoʻoalewa was flung off the Moon by the impact that created the Giordano Bruno crater. This is a 22km (14-mile) crater just on the far side of the Moon, believed to have been created relatively recently: around 4 million years ago. Sfair says that his simulations agree with this possibility.

"They ran simulations of 54,000 particles being ejected from across the Moon – 6.7 per cent came to share a similar orbit to Earth"

Overall, this new research bolsters the hypothesis that some of Earth's co-orbital bodies originally came from the Moon. Confirmation could be provided by China's Tianwen-2 mission, which launched in May 2025 to collect and return a sample of Kamoʻoalewa to Earth for analysis. By 2028, we might know for sure whether this quasi-satellite is actually a chip off the Moon.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *The Moon as a Possible Source for Earth's Co-orbital Bodies* by R Sfair, LC Gomes et al.
Read it online at: arxiv.org/abs/2505.09066

Young black holes had a growth spurt

JWST's infrared eye pinpoints when the cosmic giants stopped growing

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

I think one of the most interesting things happening in astrophysics at the minute is the rapid development of new ways to study black holes. Whether it's the virtuoso display of the Event Horizon Telescope showing us the shadow around the Milky Way's supermassive black hole or the gravitational wave physicists detecting the effects of far-off mergers between stellar-mass black holes, these cosmic enigmas are being scrutinised like never before.

Both of these methods tell us about individual black holes. Really, though, we want to know about the whole population: when they formed, how they grow and what effect they have on the galaxies that host them. This month's paper shows how the shiny new JWST might be able to help.

With black holes being black, spotting the glow from hot material in the accretion disc that surrounds them is how we usually detect them. Sometimes that means looking for X-rays, but only the most massive black holes with the hottest discs reliably shine in the highest-energy parts of the spectrum. Though sometimes emission from the accretion disc is seen in visible light – and it can outshine the entire rest of the galaxy, appearing as a quasar – dust surrounding the nucleus can often obscure it at these wavelengths.

At the redshift frontier

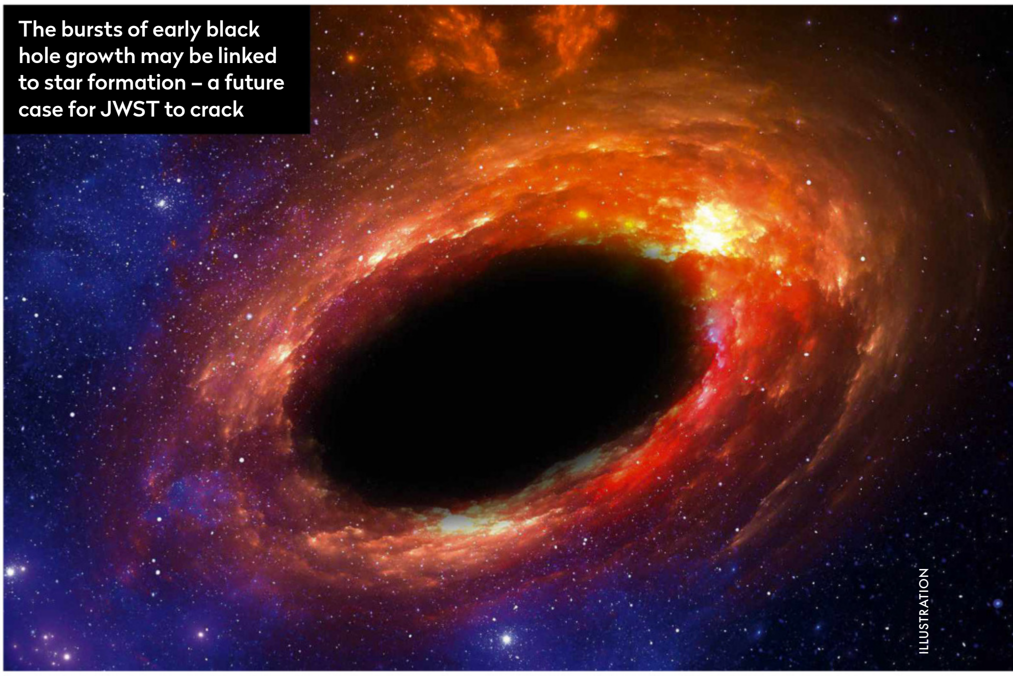
Using infrared enables us to punch through any obscuration, and JWST's giant golden mirrors allow the detection of actively growing black holes that are eight times fainter than any seen with the previous generation of infrared space telescopes. It's also sensitive to a broader range of wavelengths than prior missions, allowing it to spot emission from galaxies at higher redshift, revealing the state of black holes as they were back when the Universe was much younger than it is today.

The research paper uses data from the CEERS survey, one of the first sets of deep images taken by JWST. Combing through it, the team found 41 galaxies that harbour clearly growing black holes. By measuring their brightness at different wavelengths, the researchers were able to work out how much material they're consuming. They then did some fancy statistical footwork to convert this to what's called a luminosity function – a model that gives us the total amount that the entire population of black holes is growing by as a function of cosmic time.

Based only on one survey, and on just 41 galaxies, this is more of a preliminary study than the last word on the subject, but the overall story is clear: black hole activity grew from the Universe's early days, until a period roughly four billion years after the Big Bang, since when it has been declining.

> ***"The story is clear: black hole activity grew until roughly four billion years after the Big Bang, since when it has been declining"***

Intriguingly, this is around the time that astronomers think that star formation peaked in the Universe, so the process of star formation and black hole growth seems to have been evolving together. Future surveys will tell us whether that's because one controls the other – or whether some other factor is driving both.



The bursts of early black hole growth may be linked to star formation – a future case for JWST to crack

ILLUSTRATION

Chris Lintott was reading... *Inferring Obscured Cosmic Black Hole Accretion History from AGN Found by JWST/MIRI CEERS Survey* by C-A Hsieh et al.
Read it online at: arxiv.org/abs/2505.24308

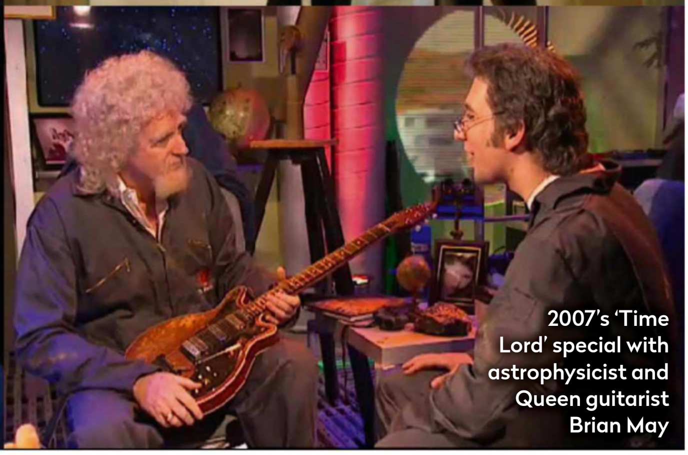
Behind the scenes of *The Sky at Night* TV show

INSIDE THE SKY AT NIGHT

A young Chris first hit the small screen with Sir Patrick Moore in 2000

With Astronomer Royal Sir Martin Rees to honour his 80th birthday in 2022

Excitement in the auditorium at mission control as New Horizons made its fly-by of Pluto in 2015


2007's 'Time Lord' special with astrophysicist and Queen guitarist Brian May

July marks a milestone for **Chris Lintott** – 25 years appearing on *The Sky at Night*. Here he reflects on cosmic discoveries and standout moments from his time on the show

I find it hard to believe it's been 25 years since I appeared on *The Sky at Night* for the first time. A scared student in a new suit, I'd been invited by Patrick to discuss viewers' questions, which ranged from 'Why are there seasons?' to 'What, precisely, is dark energy?'. While some of the questions are the same today, everything else is different.

For starters, the show back then was filmed in the corner of a vast studio at BBC Television Centre in west London, with camera operators gliding around and instructions from the producers in our ears. As the cameras got smaller, we moved to Patrick's home, Farthings, and for many years we've travelled the world (well, mostly the UK). But what has changed in astronomy in 25 years?

Professional astronomy has gone multi-messenger, with researchers regularly combining results from gravitational wave observatories and studies of particles like neutrinos with traditional techniques.

Chris Lintott is an astrophysicist and co-presenter of *The Sky at Night* since 2000

The starkest change, though, has been in what amateur astronomers can achieve from their back gardens. As the pages of this magazine demonstrate, what astrophotographers can now do with relatively modest equipment is simply astounding, whether looking at the deep sky or at nearby planets.

Speaking of planets, there are thousands more known than when I started on the show. The biggest scientific advance is undoubtedly the discovery that exoplanets are common in the Galaxy. We cover the topic regularly, sometimes focusing on the search for Earth-like worlds and sometimes emphasising the diversity of the planets that have been found.

Each of these systems has something to teach us about how our own Solar System has formed and evolved. We've learnt, too, from our neighbouring planets – Venus, which might have phosphine-burping bacteria (the subject of a memorable programme involving a guitar, toast and a lot of excitement), but particularly Mars.

BBC X 5, COLIN MCPHERSON/GETTY

> *"The starkest change has been in what amateur astronomers can achieve from their back gardens"*

The Red Planet has been explored by the rovers Spirit and Opportunity, Curiosity and Perseverance, along with orbiters loaded with cameras and sensors, and has turned out to have a fascinating history. Cassini explored Saturn and its moons, landing the Huygens probe on Titan and then, in 2006, discovering the fountains of Enceladus.

Juno has sent back marvellous pictures of Jupiter (guided by amateur astronomers on Earth) and, of course, we were on hand when New Horizons swept past Pluto, revealing a much more complex world of ice mountains and changing surfaces than expected.

In fact, everywhere we've looked in the Solar System, we've found new puzzles and mysteries. Nowhere is this more true than with the Solar System's minor bodies, from comet Churyumov–Gerasimenko explored by plucky Rosetta, to Dawn and Ceres, and more recently, small asteroids like Bennu and Ryugu.

In light of new funding challenges, we may look back on the first quarter of the 21st century as a golden age of planetary exploration. Still, we have JWST in orbit, whose first images it was a joy to share. We knew a large infrared telescope would be game-changing, but its discoveries – from 'little red dots' and mysteriously mature early galaxies to intriguing exoplanet spectra – have been magnificent.

How to watch
Catch the show on the BBC iPLAYER

▲ **A memorable moment from 2022's 'The Multiverse of Mystery' episode, where four Chrises teamed up to explain the concept of the multiverse**

Where we haven't made much progress is in cosmology. Though Planck, whose launch we travelled to see, produced the definitive map of the cosmic microwave background's ancient light, movement on the big questions – the nature of dark matter and dark energy – has been frustratingly stalled, to the extent that the answers I gave in our recent 'Question Time' episode weren't far off what I said in my first appearance.

But with a new generation of experiments coming on stream, the next 25 years could see us reporting on a new, deeper understanding of the Universe on the largest scales. I hope so – and I hope to still be on *The Sky at Night*, talking about them.

The Sky at Night
AUGUST

Make way for royalty: Dame Jocelyn Bell Burnell, the Pulsar Queen

Queen of Pulsars

In the August episode, *The Sky at Night* gets the chance to sit down with Jocelyn Bell Burnell, the astronomer who – as a 24-year-old PhD student – discovered pulsars, which are rapidly spinning neutron stars. Tune in as the team look back at Bell Burnell's work, life and legacy, while also exploring the science of pulsars and what they can tell us about the Universe.

BBC Four, **11 August**, 10pm (first repeat will be on BBC Four, **15 August**, 1:35am)
Check www.bbc.co.uk/skyatnight for more up-to-date information

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MESSAGE OF THE MONTH

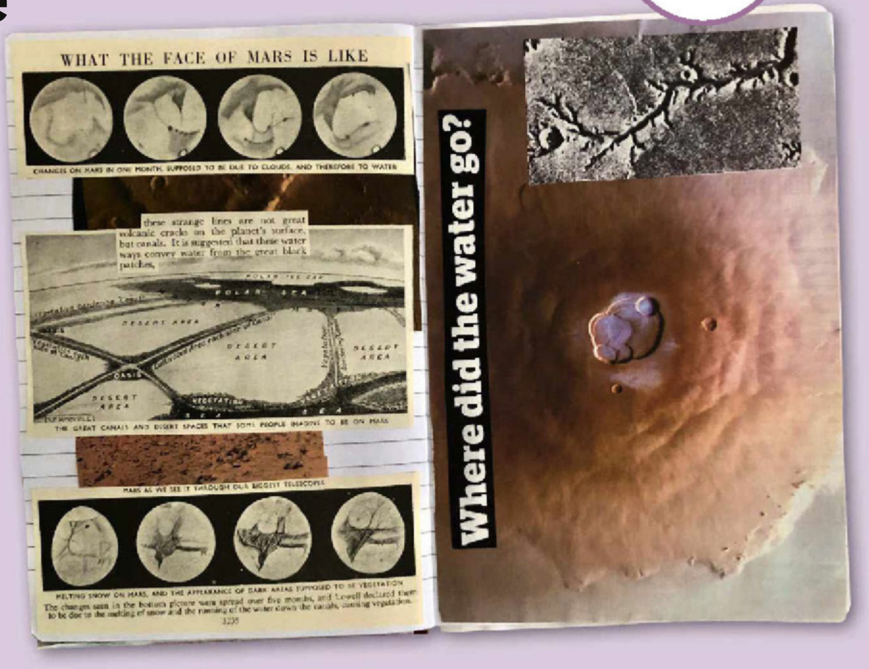
Make art, not waste

I've never considered myself artistic, but I recently began experimenting with collages. Before I recycle my monthly issue of *BBC Sky at Night Magazine*, I take clippings of the most eye-catching images, illustrations and titles. This is my favourite collage so far (right): cuttings from your magazine about Mars's seemingly arid surface, contrasted with text and illustrations from an outdated astronomy encyclopedia speculating on the Red Planet's agriculture, giving a fantastical sense of humanity showing up late to the Martian party.

Not only does this highlight how far our knowledge has come, but it reminds us that we still have so much to learn – which makes me excited always for the future. Thank you for making your magazines so visually stunning, as well as informative; the two together can be quite an inspiration!

Zak Mullin, Manchester

What a great way to reuse the monthly issues. Thank you for sharing, Zak! We wholeheartedly approve of your creativity. ***– Ed.***


WHAT THE FACE OF MARS IS LIKE
DESERT AREA
POLAR SEA
OASIS
VEGETATION
Where did the water go?

▲ **Zak's Mars collage contrasts cuttings from the mag with excerpts from vintage astronomy books. It just shows how far Red Planet science has come!**

Tweet

Steve Liddiard
@Stevelid • 12 June
Strawberry Moon rising above the reindeers of Gower. Three Crosses, Gower. #wales @skyatnightmag

Phrases of the Moon

Thank you very much for your very informative article about the Strawberry Moon (See the Strawberry Moon Tonight, www.skyatnightmagazine.com). As someone who has worked at a Native American tribe in the United States (Red Cliff and Ojibwe/Chippewa tribe), I can confirm that a Strawberry Moon is one of the Moons on the lunar calendar in the tribe. The Ojibwe people are related to the Algonquin mentioned through history, language and culture.

My thought is that instead of saying the name is "derived from Native American culture, especially the Algonquin tribe", it might be better to say the name is "found among several Native American cultures and existed historically within the Algonquin tribe". It's inaccurate to suggest there is one Native American culture. I'm not a descendant of North America's first people and I don't presume to speak for any tribal nation; these are my thoughts and opinions, as someone who lives in the woods, practices and teaches wilderness skills, and has been involved in tribal life.

Alex Breslav, via email

Mission: delusional

I completely agree that we should not invest in a crewed Mars mission (Inside the Sky at Night, June 2025). That money could help so much with climate change issues. And Mars is not a safe house. It is, as your author stated, just about making money and feeding arrogance. Thank you for your article!

Cindy Davis, via email

The case for Mars

I was dismayed by the June issue Inside the Sky at Night article that reiterates the idea that we should abandon human space exploration, or limit ourselves to ▶

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▶ Earth orbit. Robotic exploration is good, but it doesn't generate the public support of astronauts and entails a comms lag that hampers exploration. Additionally, having Mars as a 'backup' requires that we continue to inhabit Earth. Regarding dogs, however, I share the disappointment.
Zac Barnes, Norwich

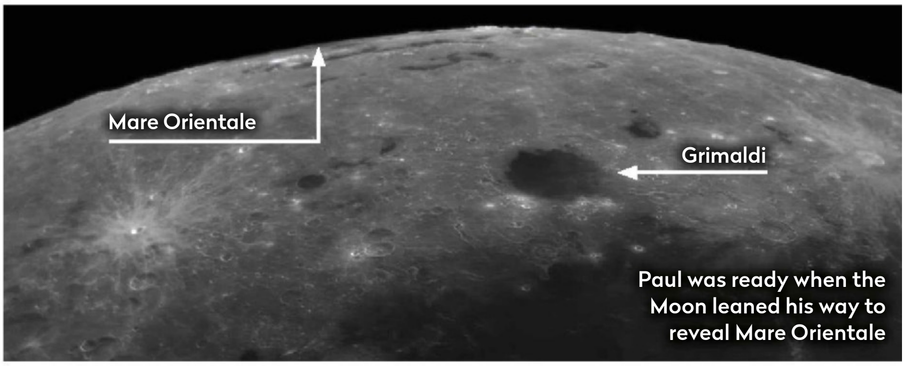
Instagram

Bhumphreysphotography
12 June
June's absolutely mesmerising Strawberry Moon. I sat myself in a field and patiently waited for the moonrise, immersed in nature and surrounded by wildlife. @bbcskyatnightmag

Libration heads-up

Thank you for letting readers know about the favourable libration for seeing Mare Orientale during May 2025 (Sky Guide, May Highlights). The weather in the northeastern USA has not often favoured observation this spring, but on 20 May it was clear enough to get this view (below): Mare Orientale is right on the limb of the Moon, just left of centre.

Also well presented is the crater Grimaldi, above the dark expanse of Oceanus Procellarum at the lower right corner. It was taken with a Celestron NexStar 6SE scope and a ZWO ASI662MC camera with IR and yellow filters fitted, with the best 1,000 of 6,000 frames stacked and then converted to greyscale.
Paul Lahti, via email



Paul was ready when the Moon leaned his way to reveal Mare Orientale

SOCIETY IN FOCUS

The **Edmonton Centre of the Royal Astronomical Society of Canada** (RASC) was formed in 1932. Members participate in outreach, observing, meteorite hunts and programming the Queen Elizabeth II Planetarium, which operated 1960–1983 and remains in use by the Telus World of Science Edmonton (TWOSE).

We have 240 members and meet monthly at TWOSE's Zeidler Star Theater. An all-volunteer group, we prioritise public education, visiting schools, youth groups and senior centres. We've hosted speakers like Alan Stern and Jocelyn Bell Burnell.

We operate the Royal Astronomical Society of Canada Observatory, with six pier-mounted telescopes, including a 6-inch solar scope. It's open weekend nights, summer days and for special events. On one night in January 2025, 2,000 people visited for a planetary lineup. We host Milky Way Day at Elk Island National Park and participate in the Jasper Dark Sky Festival.

▲ RASC regularly draws a crowd to observing events at their observatory

In Edmonton, winter nights are long, summer nights are short and we're in perpetual twilight from mid-May to the end of July (when we're in an ideal location to view noctilucent clouds). Since 1932, we've inspired astronomical exploration, free to all.
Geoff Robertson, public education director
▶ **www.edmontonrasc.com**

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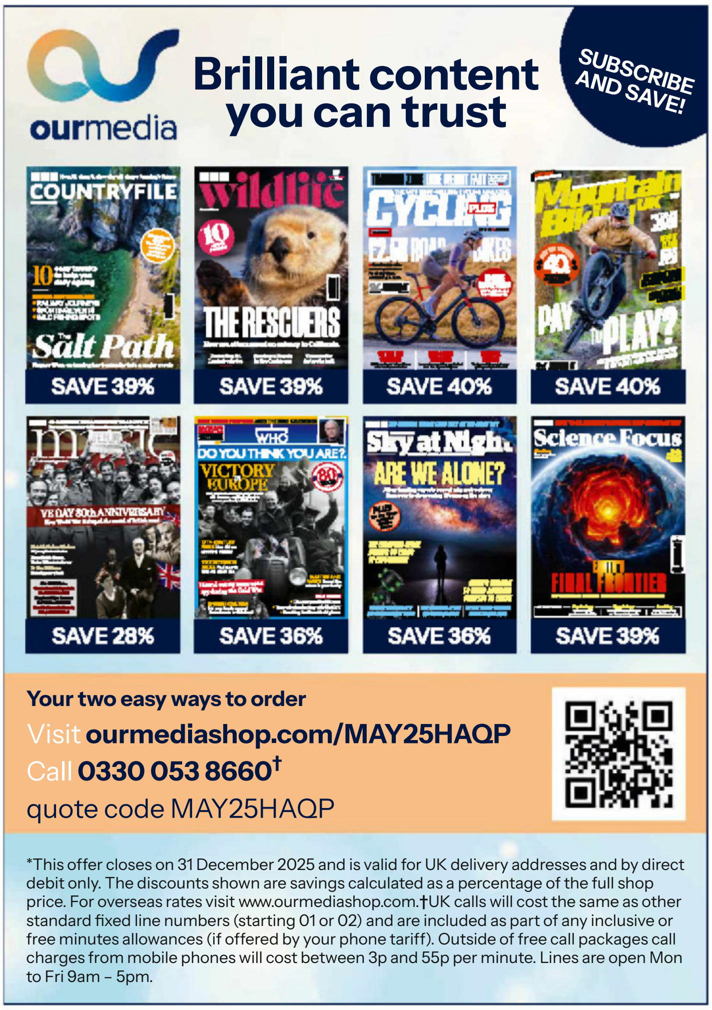

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FIELD OF VIEW

The odds say no... yet here we are

When you consider the infinitesimal chance of humans evolving, life becomes one of the Universe's rarest, most precious things, says **Mark Westmoquette**

JIA-YI-LIU/FOLIO

There's a meme that's been floating around on social media recently, offering encouragement to turn our everyday perspective upside down: "In the entire Universe, wood is rarer and more valuable than diamonds." While diamonds are surprisingly common in the Universe – being made from (very abundant) carbon crystallised in the high pressures of asteroid collisions and gas giant atmospheres – wood is stupendously rare. It requires life and a whole succession of evolutionary inventions, like DNA and photosynthesis – not to mention the presence of liquid water and a stable atmosphere. As far as we know, these conditions exist only on Earth.

And if wood is rare, what about an intelligent, self-aware, communicative and inquisitive being, such as... you?

In 1961, Frank Drake came up with an equation to calculate the odds of intelligent life evolving. It has five factors: 1) the rate of formation of stars suitable for the development of life (some stars are very unstable or violent); 2) the fraction of those stars with planets; 3) the number of planets per star that are suitable for life; 4) the fraction of those planets on which life actually appears; and 5) the fraction of those on which intelligent life evolves.

Currently, we only have numbers for the first two: we know there are around six or seven new stars born each year in the Milky Way, and it seems likely that the majority of stars have at least one planet. Estimates for the number of those planets suitable for life (meaning the planet needs to be the right size and temperature) suggest hundreds of millions of potentially habitable planets in our Galaxy.

How many of those actually develop life we can only guess about. So far, we only know it happened on our planet, but if we're optimistic, we could assume that simple algae-like life develops on most suitable planets. However, algae is a far cry from trees. And making the jump from trees to intelligent life? Again, we can only guess. Whether or not you're an optimist, life must certainly be one of the most rare and most precious things in the Universe.

Drake extended his equation to consider the chance of finding other intelligent civilisations by adding two further factors: 6) the fraction of civilisations that develop technology that we could detect (such as radio signals, laser beams or spaceships); and 7) the length of time those civilisations exist for (considering the vast distances of space). Humans have only been making signals that could be detected in space for about 100 years.

If you put all this together with some reasonable guesses, you end up with about one planet with intelligent life per galaxy at any one time. So, we're it! That means that human life – your life – is extraordinarily rare and that all life is deeply precious. You are one of the most incredible beings that has ever been created by this Universe.

Our mental health takes a plunge when we see ourselves and the life around us as something that doesn't matter. The ecosystem then becomes just something to serve us and we stop caring. But, by turning this perspective upside down and recognising the value and rarity of life, we find a deeper connection and appreciation for all living things.

Author of *The Mindful Universe*, astronomer and mindfulness teacher **Mark Westmoquette** lives in London with his young family

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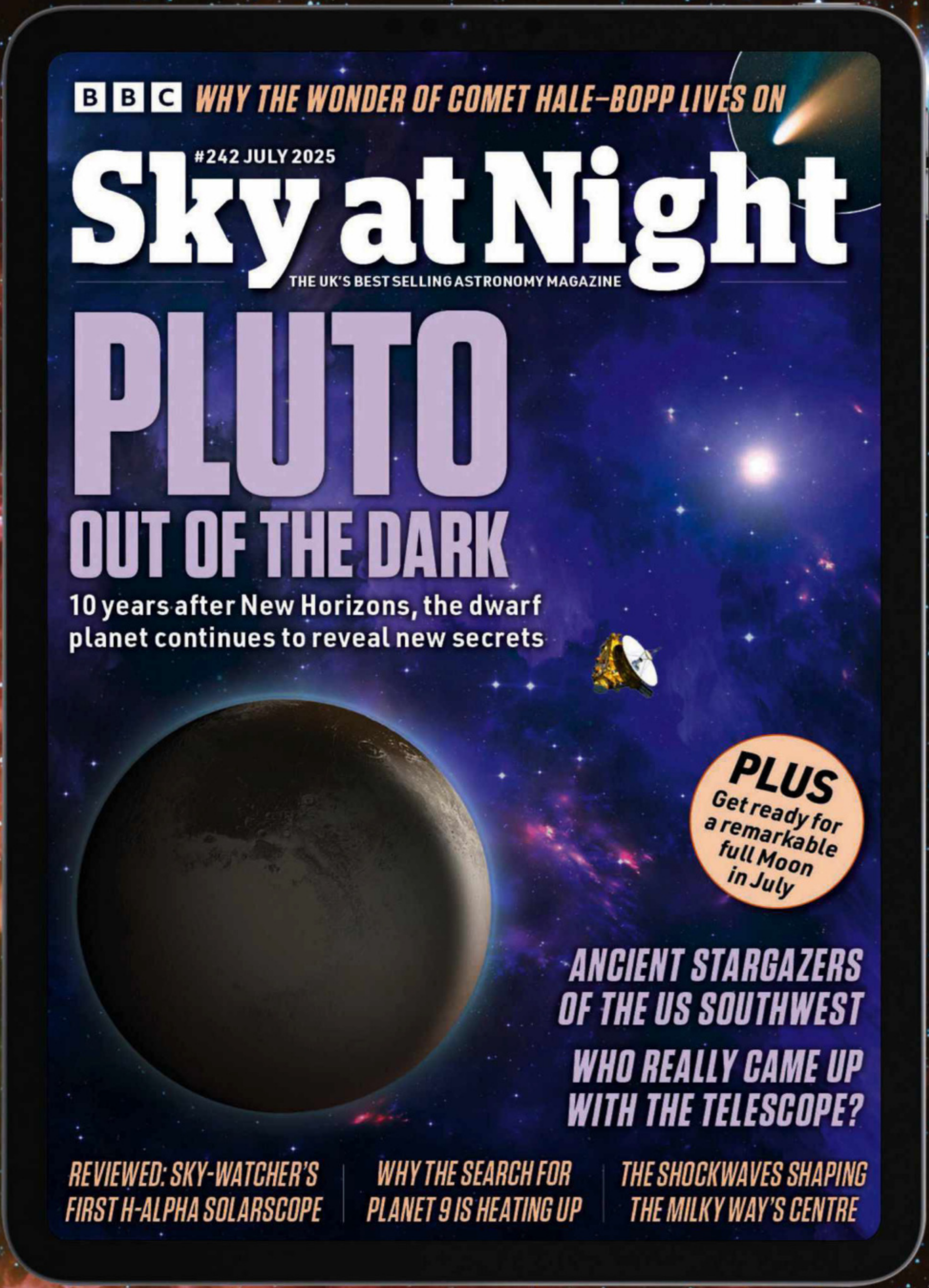
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News

The Royal Observatory Greenwich

An untold history

As it celebrates its 350th anniversary, **Emily Winterburn** uncovers some of the hidden figures – from instrument-makers to YouTubers – behind one of the world's earliest official astronomy institutions

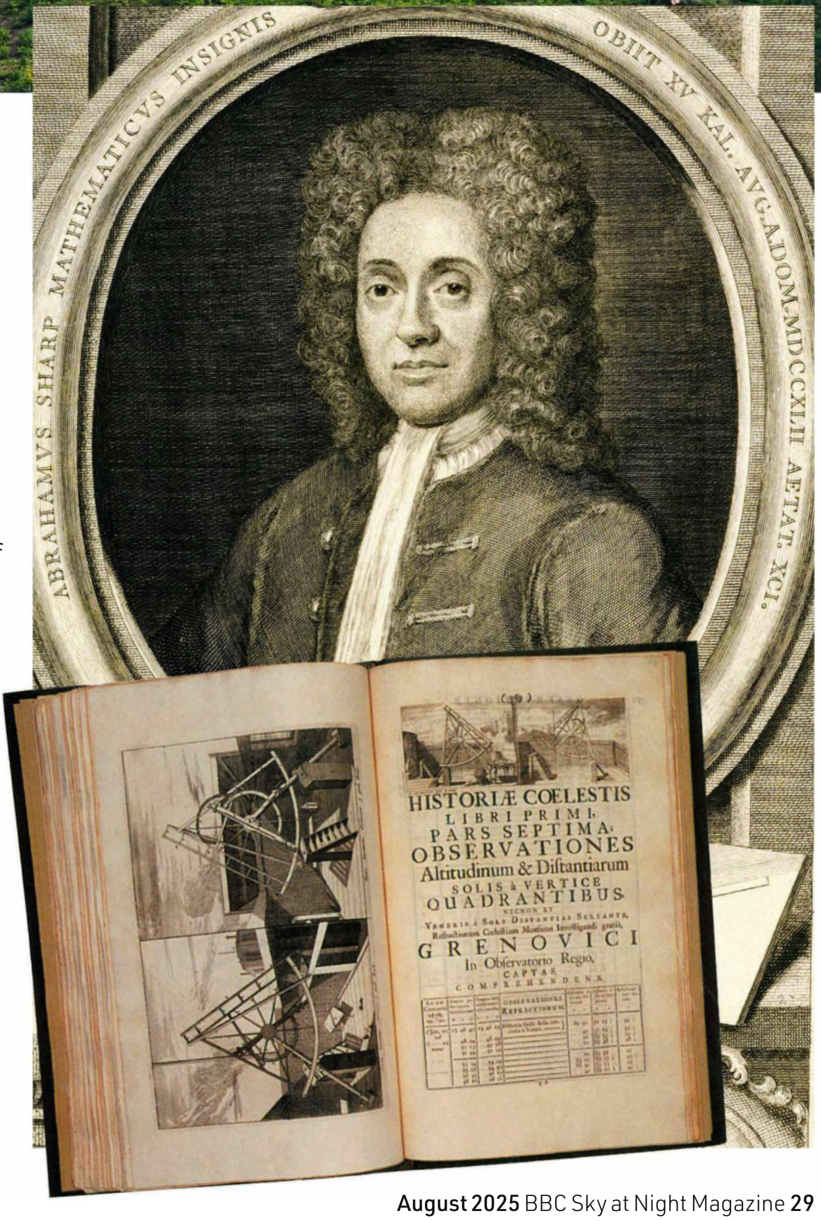
The Royal Observatory isn't all about star names. Many unsung heroes contributed to its worldwide reputation

This month marks the 350th anniversary of the Royal Observatory Greenwich, a cornerstone of modern astronomical science. Founded in 1675, this grand institution is known as the home of Greenwich Mean Time and Prime Meridian, where visitors flock to stand astride the line marking 0° longitude. While the spotlight often falls on those at the top, the Astronomers Royal, the Observatory's legacy has also been shaped by a host of unsung others: instrument-makers, observers, human 'computers' and civil servants whose work underpins centuries of scientific discovery. To mark the anniversary, we take an alternative look at the Royal Observatory and some of those who have shaped its remarkable history.

Abraham Sharp (c1653–1742)

We begin our story not with John Flamsteed, the first Astronomer Royal, but with his instrument-maker Abraham Sharp. The son of a wool merchant, Sharp grew up in Bradford, northern England, and attended Bradford Grammar School. His career began at first as a schoolteacher and writer on mathematics in Liverpool, after which he moved to London where he encountered various mathematicians at the city's coffee houses – the favourite place for discussion and intellectual exchanges before the growth of learned societies. It was here that he came to the attention of Flamsteed, who invited Sharp to join him at the Royal Observatory in 1684.

While at the Observatory, Sharp assisted Flamsteed with calculations, and designing and building astronomical equipment, including the groundbreaking mural arc in 1689. This was a graduated arc mounted on a wall and fitted with a telescopic sight; used in conjunction with a clock, it allowed Flamsteed to map the first-ever star atlas produced using a telescope. Work at the new Observatory in the late 17th century, however, does not seem to have been very secure, and Sharp's career continued as one of a peripatetic mathematician, finding work where he could as instrument-maker, computer and teacher. ▶



▶ **The best-known of Flamsteed's assistants, Abraham Sharp has a Moon crater named after him; Sharp's instruments were vital in compiling his boss's star atlas**

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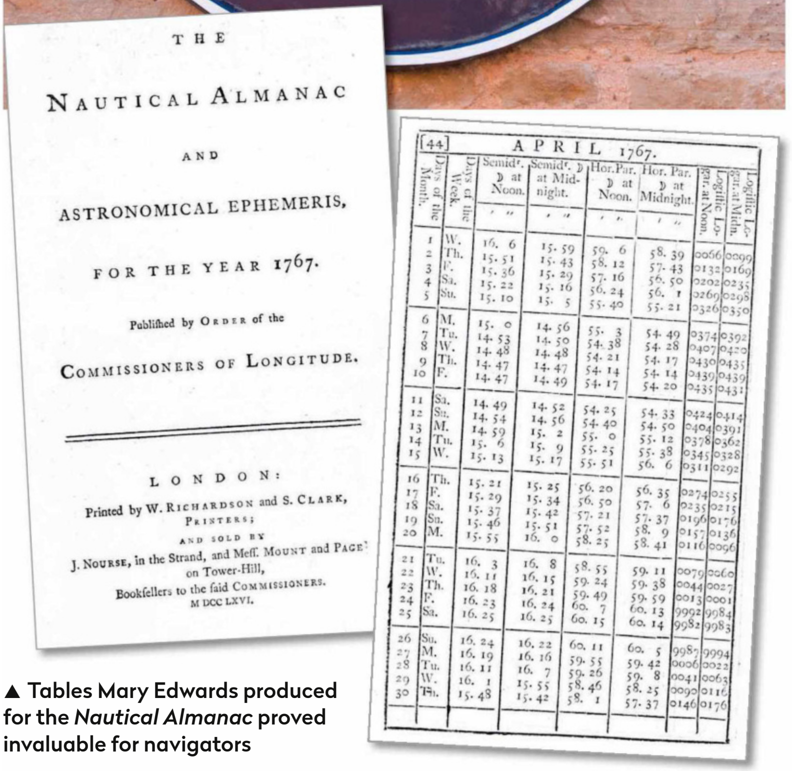
LUDLOW CIVIC SOCIETY
Mary Edwards
1750-1815
First female "Computer"
lived and worked from 4 Brand Lane.
She was employed by the Board of
Longitude to compute astronomical
tables for the
British Nautical Almanac
between 1773 & 1815

▶ **Mary Edwards's precise calculations made her a true pioneer as an Observatory computer**

Mary Edwards (c1750–1815)

By the late 18th century, the problem of longitude had become a central and fairly bureaucratic part of the Observatory's work. Under Nevil Maskelyne (the fifth Astronomer Royal), the Observatory had created the *Nautical Almanac*, a yearly publication of Sun, Moon, planet and star positions 'reduced' into a form that was usable by navigators at sea. The 'reducing' of that data took hours of careful, meticulous, laborious work and was done as piece-work by 'computers' – a term long used for a person who undertook calculations – working in their homes with raw data and piles of books (including logarithmic tables) sent out by the Observatory.

Mary Edwards was one such computer. Originally, it was her husband who had been employed by the Observatory, but following his death, she asked if she could take over the role; Maskelyne – never one to defend the exclusion of women from the sciences – said she could. On closer examination, it appeared she had been doing the work all along. Not only that, but she developed a reputation for great accuracy and went on to train her daughter Eliza, who became a computer alongside her mother and then independently after Mary died in 1815.



THE

NAUTICAL ALMANAC

AND

ASTRONOMICAL EPHEMERIS,

FOR THE YEAR 1767.

Publiſhed by ORDER of the

COMMISSIONERS OF LONGITUDE.

LONDON:
Printed by W. RICHARDSON and S. CLARK,
PRINTERS;
AND SOLD BY
J. NOURSE, in the Strand, and Meſſ. MOUNT and PAGE
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M DCC LXVI.

[44] APRIL 1767.

Days of the Month.	Days of the Week.	Semid^r. ☽ at Noon.	Semid^r. ☽ at Midnight.	Hor. Par. ☽ at Noon.	Hor. Par. ☽ at Midnight.	Logiſtic Logar. at Noon.	Logiſtic Logar. at Midn.
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2	Th.	15. 51	15. 43	58. 12	57. 43	0132	0169
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5	Su.	15. 10	15. 5	55. 40	55. 21	0326	0350
6	M.	15. 0	14. 56	55. 3	54. 49	0374	0392
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8	W.	14. 48	14. 48	54. 21	54. 17	0430	0435
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11	Sa.	14. 49	14. 52	54. 25	54. 33	0424	0414
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13	M.	14. 59	15. 2	55. 0	55. 12	0378	0362
14	Tu.	15. 6	15. 9	55. 25	55. 38	0345	0328
15	W.	15. 13	15. 17	55. 51	56. 6	0311	0292
16	Th.	15. 21	15. 25	56. 20	56. 35	0274	0255
17	F.	15. 29	15. 34	56. 50	57. 6	0235	0215
18	Sa.	15. 37	15. 42	57. 21	57. 37	0196	0176
19	Su.	15. 46	15. 51	57. 52	58. 9	0157	0136
20	M.	15. 55	16. 0	58. 25	58. 41	0116	0096
21	Tu.	16. 3	16. 8	58. 55	59. 11	0079	0060
22	W.	16. 11	16. 15	59. 24	59. 38	0044	0027
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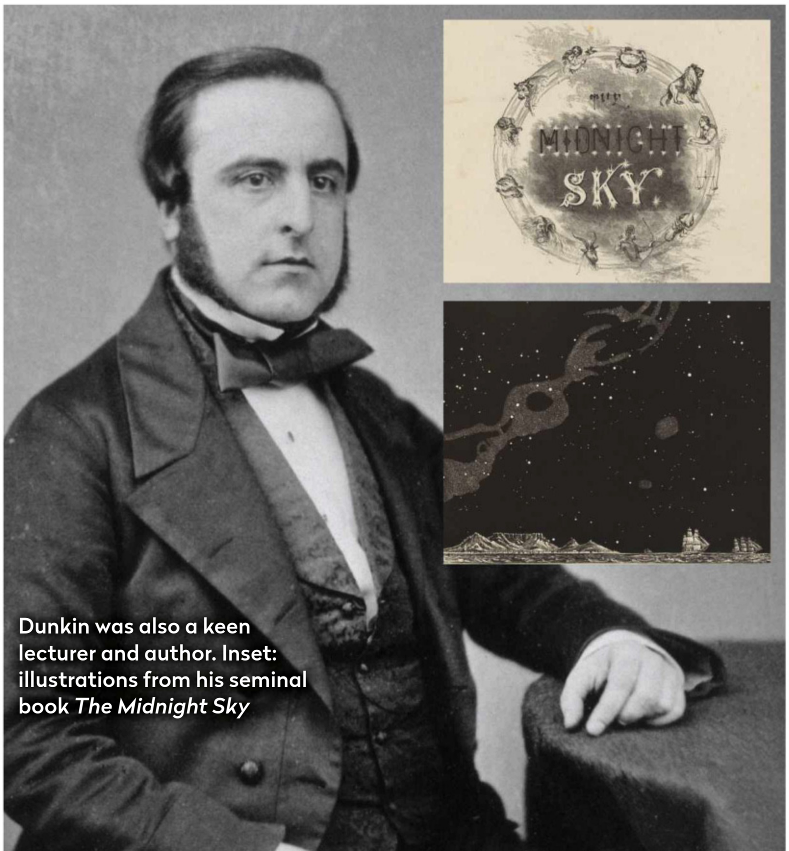
24	F.	16. 23	16. 24	60. 7	60. 13	9992	9984
25	Sa.	16. 25	16. 25	60. 15	60. 14	9982	9983
26	Su.	16. 24	16. 22	60. 11	60. 5	9987	9994
27	M.	16. 19	16. 16	59. 55	59. 42	0006	0022
28	Tu.	16. 11	16. 7	59. 26	59. 8	0041	0063
29	W.	16. 1	15. 55	58. 46	58. 25	0090	0116
30	Th.	15. 48	15. 42	58. 1	57. 37	0146	0176

▲ **Tables Mary Edwards produced for the *Nautical Almanac* proved invaluable for navigators**

Edwin Dunkin (1821–1898)

Edwin Dunkin worked for the Observatory for nearly 50 years, first under George Biddell Airy (the seventh Astronomer Royal), then Airy's successor, William Christie. Edwin had grown up in Cornwall, where his father had worked for the *Nautical Almanac*. Like Shropshire-based Mary Edwards, he carried out computations for the publication from home. When the *Nautical Almanac* set up offices in London's Somerset House, the Dunkin family moved to the city. After his father died, Edwin, then aged 17, started work at the Observatory as a computer, collecting additional data for the Admiralty and becoming assistant in the new Magnetic and Meteorological department. In 1845, he moved again to become an assistant in the Astronomy department and gradually worked his way up the ranks, eventually becoming Chief Assistant when Christie became Astronomer Royal.

Alongside his work at the Observatory, Dunkin was a keen and successful promoter of astronomical education among the general public, writing books and giving lectures. Most famous, and still loved by many astronomers today, was *The Midnight Sky*, a



Dunkin was also a keen lecturer and author. Inset: illustrations from his seminal book *The Midnight Sky*

MIKE HAYWARD/ALAMY STOCK PHOTO, © NATIONAL MARITIME MUSEUM X 4, ROYAL ASTRONOMICAL SOCIETY/SCIENCE PHOTO LIBRARY, CBW/ALAMY STOCK PHOTO, WELL/BOT/ALAMY STOCK PHOTO, HULTON ARCHIVE/ STRINGER/GETTY

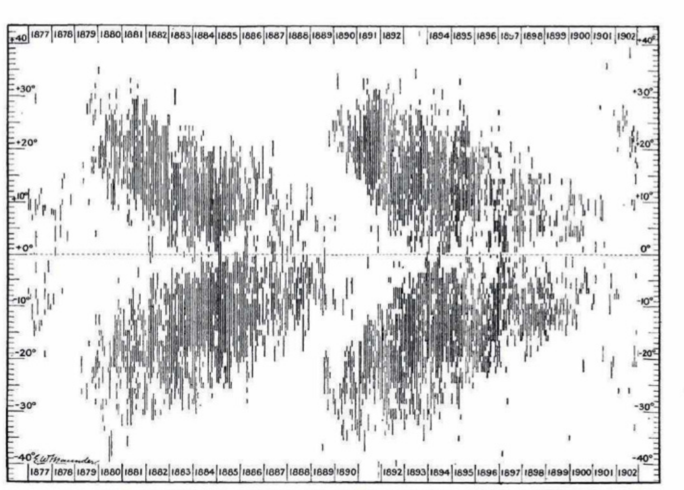


FIG. 8.—DISTRIBUTION OF SPOT-CENTRES IN LATITUDE, ROTATION BY ROTATION. 1877–1902.

▲ **Left: Despite the professional restrictions placed on her as a woman, Annie Maunder devoted her life to solar astronomy**

▲ **Right: Maunder's work in the Observatory's Solar department led to a greater understanding of the cyclical nature of sunspot activity**

beautifully illustrated guide to the night sky, with maps showing the stars above a London skyline as seen from the Greenwich Observatory.

Annie Maunder (née Russell, 1868–1947)

Throughout the 19th century, the remit of the Observatory grew, incorporating the study of solar astronomy, photography and spectroscopy. It also began to collaborate with other observatories on international projects.

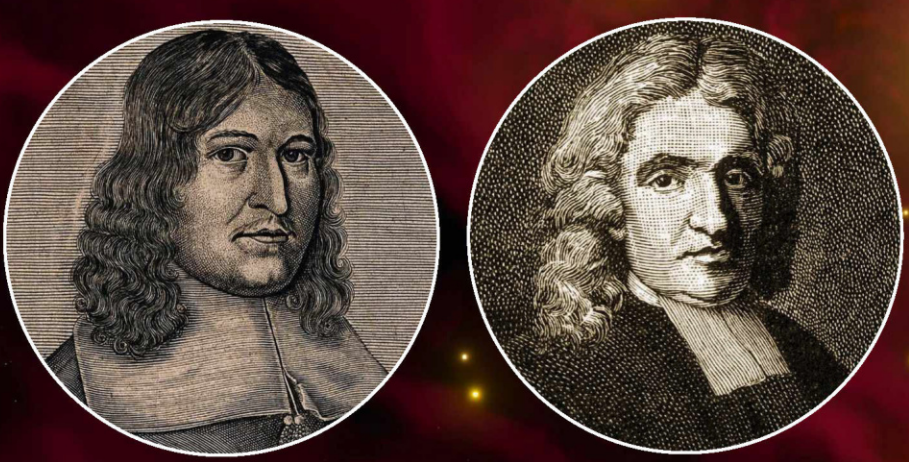
Born Annie Russell, Maunder grew up in Northern Ireland and went to school in Belfast, before receiving a scholarship to Girton College, Cambridge. After a brief stint as a teacher, she joined her friend Alice Everett at the Observatory in 1891, first as a computer and then in the Solar department. Here she used the Dallmeyer photoheliograph to photograph sunspots, noting their shape, position, size and frequency over time. Soon, she began to spot patterns. Working with Walter Maunder, whom she married in 1895, they plotted their observations and came up with the 'butterfly' diagram (above) that showed the regular cycle of sunspot activity.

As a woman, Maunder did not receive a degree (Cambridge didn't award these to women until 1947), was paid significantly less than men at the Observatory and had to give up her post after she married (though she continued unpaid). The Royal Astronomical Society would not let her become a member until 1916, but the British Astronomical Association welcomed her and she became an active member. She and her husband went on many eclipse expeditions, learning more about the Sun. The couple also, like Edwin Dunkin, wrote books to encourage others into astronomy. Their best-known, *The Heavens and Their Story*, is still in print today. ▶

Charting the heavens to rule the seas

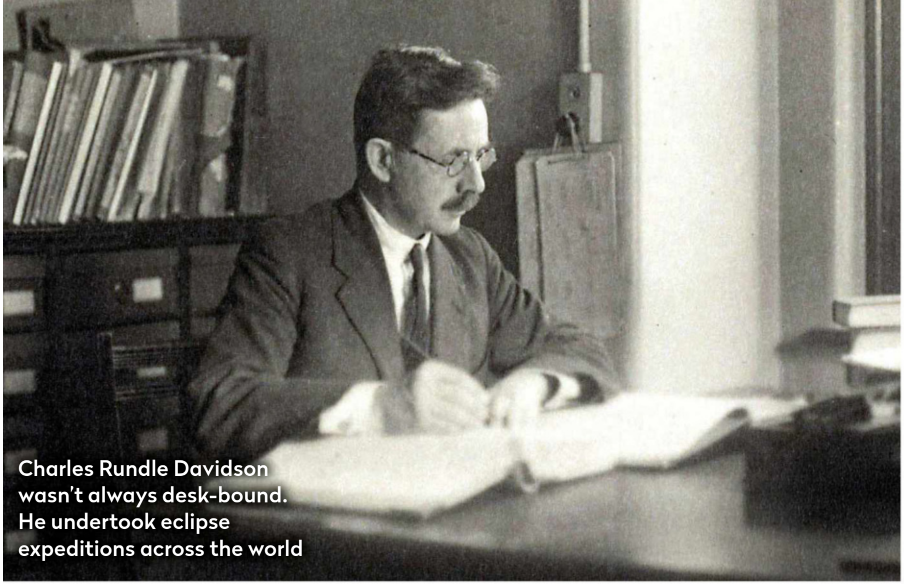
Astronomers were crying out for an observatory – the navigation problem made it happen

On 10 August 1675 at 3:14pm, John Flamsteed laid the foundation stone of the Royal Observatory on a hill in Greenwich Park, London. On the surface, the story of the first state-funded scientific institution in Britain is one of power and monarchy. Charles II, wishing to solve the navigational problem of longitude before the French, quickly established the Observatory in Britain. Its purpose was to produce accurate observations of the stars and Moon at any given time, so that navigators might plot their position against Greenwich time wherever they went.

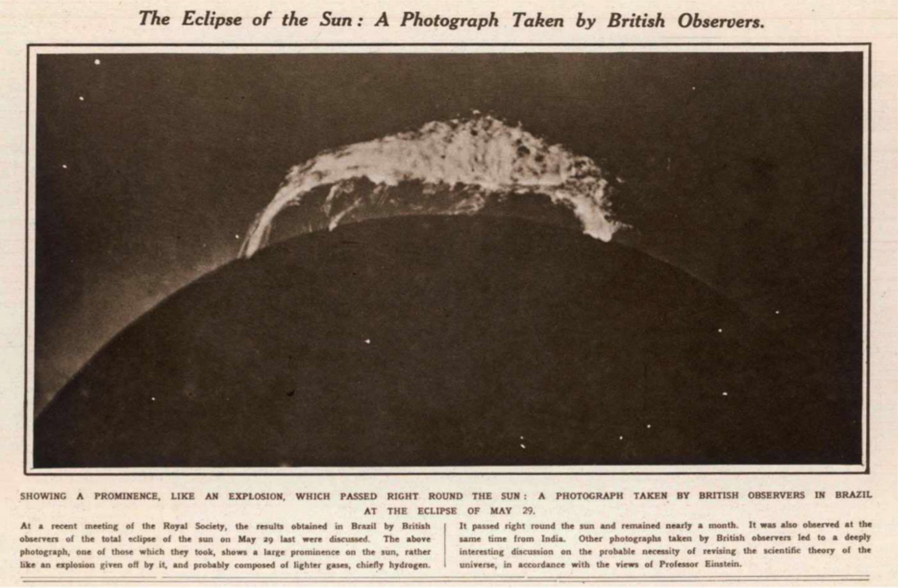


▲ **The wealthy and influential Jonas Moore (left) was instrumental in the building of the Observatory at Greenwich. John Flamsteed (right) would be its first Astronomer Royal**

Behind the scenes, however, several scientific men had already been making plans for such an institution. The wealthy and influential Jonas Moore, Flamsteed's patron since 1670, had been seeking support for an observatory for years. Flamsteed, meanwhile – an astronomy enthusiast since childhood – had come to learn about observing and instrumentation, written papers on the topic, and cultivated connections with the scientific elite. When the king decided an observatory was needed, Moore and Flamsteed were primed; this was the opportunity both had been waiting for. And so it was that Moore's friend Sir Christopher Wren came to design the new building, where Flamsteed spent the rest of his life creating the first-ever star atlas and catalogues.



Charles Rundle Davidson wasn't always desk-bound. He undertook eclipse expeditions across the world



The Eclipse of the Sun: A Photograph Taken by British Observers.

SHOWING A PROMINENCE, LIKE AN EXPLOSION, WHICH PASSED RIGHT ROUND THE SUN: A PHOTOGRAPH TAKEN BY BRITISH OBSERVERS IN BRAZIL AT THE ECLIPSE OF MAY 29.

At a recent meeting of the Royal Society, the results obtained in Brazil by British observers of the total eclipse of the sun on May 29 last were discussed. The above photograph, one of those which they took, shows a large prominence on the sun, rather like an explosion given off by it, and probably composed of lighter gases, chiefly hydrogen. It passed right round the sun and remained nearly a month. It was also observed at the same time from India. Other photographs taken by British observers led to a deeply interesting discussion on the probable necessity of revising the scientific theory of the universe, in accordance with the views of Professor Einstein.

▲ In 1919, Davidson and other British eclipse observers travelled to northern Brazil. This photograph from the trip shows an explosion-like prominence erupting on the Sun's surface

Charles Rundle Davidson (1875-1970)

Charles Rundle Davidson joined the Observatory around the same time as Annie Maunder, in 1890, when he was 15. Like many of the Observatory's employees, he had been educated at the Greenwich Royal Hospital School, a charitable institution that educated the children of seafarers primarily for low-level skilled work in commerce and navigation. Davidson, however, passed the test to work as a computer and stayed working for the Observatory for 40 years.

As well as his computations, Davidson worked as an observer and he designed, adapted and improved apparatus. His understanding of instrument design was such that when Astronomer Royal Frank Dyson made eclipse expeditions a significant part of the Observatory's work, he relied heavily on Davidson's expertise, sending him out on a total of eight expeditions. The most famous of these trips was to observe the 1919 eclipse in Sobral, Brazil. Meanwhile, Davidson's former colleague from the Observatory, by then at Cambridge, Arthur Eddington, went to the island of Príncipe off the west coast of Africa. On the day of the eclipse, conditions in Príncipe were cloudy, so when Eddington needed the proof that Einstein's theory of relativity worked, it was Davidson's results that he relied on.

Gilbert Satterthwaite (1934-2013)

Quite by chance, Gilbert Satterthwaite ended up being the last person to make an observation with the Royal Observatory's legendary Airy Transit Circle telescope before the Observatory relocated to Herstmonceux. This symbolic act was due to be performed by the Chief Assistant on 31 March 1954, but that particular day was cloudy. Satterthwaite, however, had observed with it on the

© NATIONAL MARITIME MUSEUM X 5, CHRONICLE/ALAMY STOCK PHOTO, GILBERT SATTERTHWAITE: SATTERTHWAITE FAMILY

Key moments in Royal Observatory history

1675 John Flamsteed, the first Astronomer Royal, lays the foundation stone.

1714 The Longitude Act is announced. The prize still exists for transformative scientific research. It currently honours breakthroughs in the understanding of dementia.

1766 Nevil Maskelyne publishes the first volume of the *Nautical Almanac*, an invaluable resource for sailors.

1817 Under John Pond, the Observatory begins to expand its remit beyond positional astronomy, including the collection of magnetic data for the Admiralty.

1873 The Observatory's Solar department is established under George Biddell Airy.

1881 Airy retires and former Chief Assistant William Christie takes his place as Astronomer Royal.

1884 The meridian defined by the Airy Transit Circle (installed in 1851) becomes the Prime Meridian (longitude 0°) for all the world.

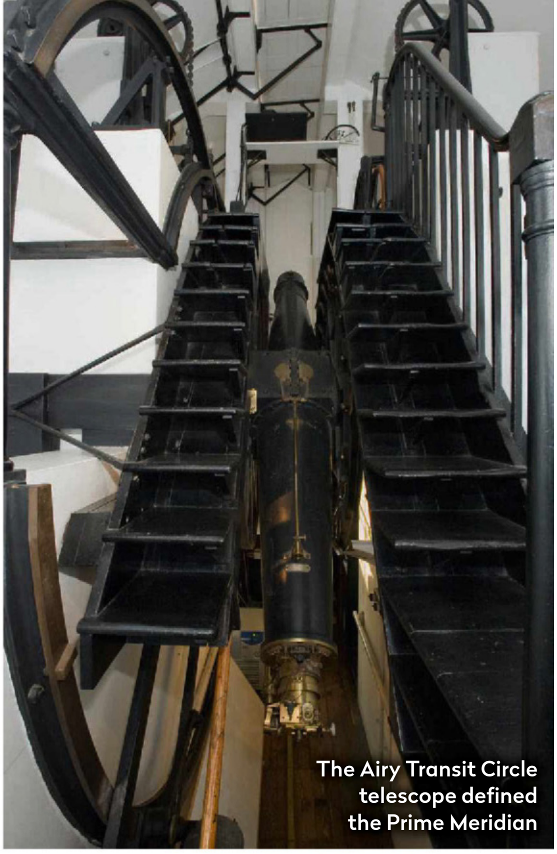
1893 The 28-inch refractor is installed, briefly becoming the largest refracting telescope in the world.

1894 The first wing of the New Physical Laboratory (The South Building) is completed. This new building would go on to house chronometric work; magnetic and meteorological work; a library and astrophotographic work.

1954 The Observatory moves to Herstmonceux in Sussex in search of less-polluted skies, becoming the RGO (Royal Greenwich Observatory). The old observatory site in Greenwich becomes a museum.

1998 Astronomers move out of Herstmonceux as observatories are established in better locations overseas. The Observatory's public understanding of science remit moves back to Greenwich.

2018 The Annie Maunder Astrographic Telescope is installed in the Altazimuth Pavilion. The dome houses a suite of four telescopes and provides a platform for imaging the full range of celestial objects.


The Airy Transit Circle telescope defined the Prime Meridian

▲ **Gilbert Satterthwaite pictured later in life alongside the Airy Transit Circle**

previous day, so it was his observation that became the instrument's last.

Satterthwaite had begun work at the Observatory less than two years earlier, aged 18, starting in the Meridian department and observing with the Airy Transit Circle. He became an expert on this instrument, even writing his MSc thesis on its 100-year history. He continued working for the Observatory in Herstmonceux until 1957.

In 1970, Satterthwaite returned to the Observatory in Greenwich (by then a museum) as a planetarium lecturer and guide, where he stayed for many years. In later years, he also took up a post in the optics lab at Imperial College.

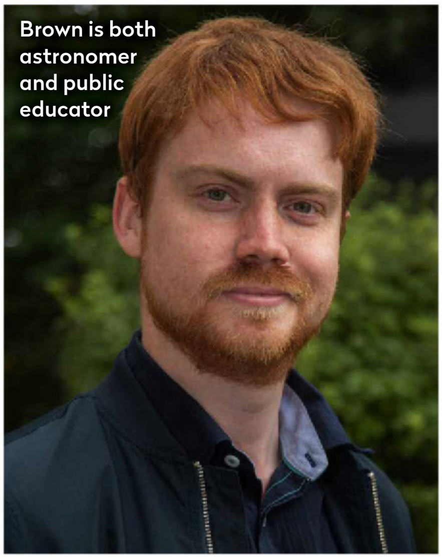
Greg Brown (1990-)

Greg Brown is one of around 40 astronomers working at the Observatory today. There is no longer an Astronomer Royal to work under (that title is now quite separate from the day-to-day workings of the Observatory), but Brown still observes, takes photographs of the night sky and shares his work and enthusiasm for astronomy with the public, just like Dunkin, Maunder and Satterthwaite before him.

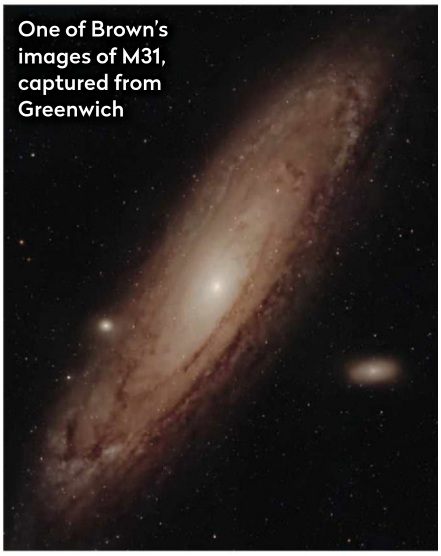
Brown trained in astronomy, gaining a PhD from the University of Warwick. During his studies, he began to get involved in science communication, running the university's planetarium. It then wasn't a huge leap to join the education team at Greenwich, where he works with school groups, gives planetarium shows and runs various events, including observing nights and Islamic astronomy mornings.

Brown also works with the Annie Maunder Astrographic Telescope (AMAT), a set of telescopes mounted in the old Altazimuth Pavilion. With the AMAT, he's been able to take beautiful pictures of nebulae and galaxies all visible from Greenwich. He has even run live streams from the dome (viewable on the observatory website or YouTube), where the public can share in the experience of seeing the night sky from Greenwich.

Emily Winterburn is the author of *The Quiet Revolution of Caroline Herschel*


Brown is both astronomer and public educator

What would Abraham Sharp make of today's technology?


One of Brown's images of M31, captured from Greenwich

From canals to Curiosity

The search for life on Mars

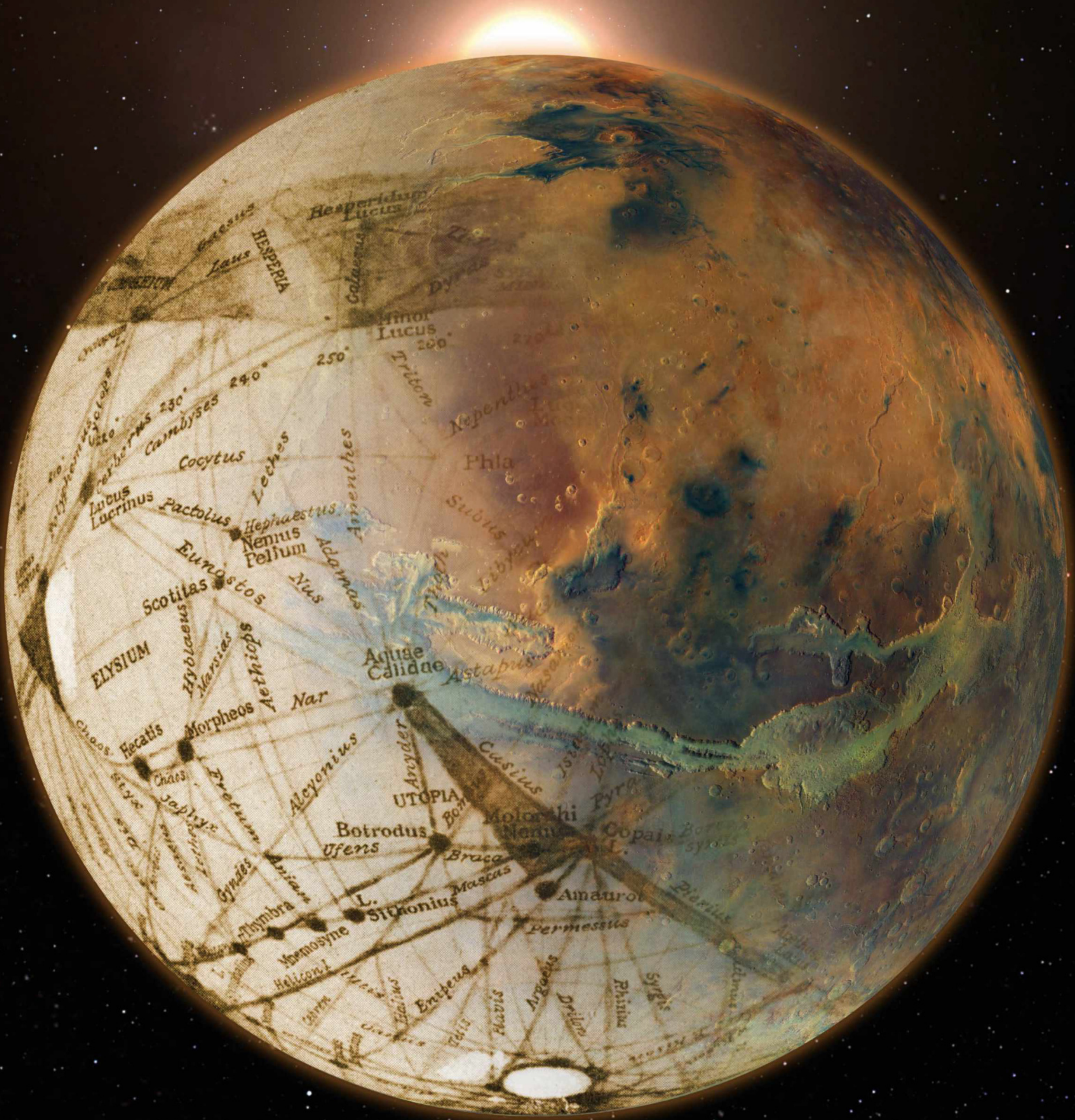
Mars has long ignited our imagination. **Ben Evans** traces the history of our quest for life on the fourth rock from the Sun

SCIENCE HISTORY IMAGES/ALAMY STOCK PHOTO, ESA/DLR/FU BERLIN/G. MICHAEL

The prospect of life on Mars – Earth's planetary next-door neighbour, an alien world that betrays tantalising hints of a watery past – has bewitched humanity for centuries. From the 'canals' seen by astronomer Percival Lowell, and HG Wells's fire-spewing tripods, to David Bowie's glam-rock croons about a girl with mousy hair, life on Mars has captured our imagination as a literal and metaphorical trope.

At first glance, the contrast between the iridescent blues, greens and tans of Earth – awash with water, teeming with life – and the barren, subfreezing, radiation-drenched Mars could hardly be more stark. Half the size of Earth and 11 per cent as massive, Mars's orbit around the Sun takes it as near to us as 56 million km (35 million miles) and as far as 400 million km (250 million miles).

Yet the pair do share similarities. Mars's 24-hour, 36-minute day mirrors our 23 hours, 56 minutes. Its axial tilt of 25.19° is close to our 23.44°, producing similar seasons. But Martian seasons last nearly twice as long, the planet's more distant orbit taking 687 days to circle the Sun compared to Earth's 365 days. ▶


Hesperidum Lucus
Laus
HESPERIA
Colaeus
Dyras
Minor Lucus
250°
200°
240°
230°
Triton
Nepenthes
Phla
Cambyses
Cerberus
Cocytus
Leches
Amenthes
Lucus Lucrinus
Pactolus
Hephaestus
Nennus Pellum
Eunostos
Scotitas
Nus
Adamas
ELYSIUM
Hyblaeus
Marsias
Aethiops
Aquae Calidae
Astapus
Nar
Morpheos
Hecatis
Chaos
Styx
Fretum
Alcyonius
Anyder
UTOPIA
Cusius
Pyra
Botrodus
Ufens
Braca
Copais L.
Gyndes
Mascas
Amauroi
Sithonius L.
Thymbra
Mnemosyne
Permessus
Pierius
Helicon L.
Enipeus
Argaeus
Drilon
Rhiaus
Syrtis

Mars attracts: discover how our sci-fi dreams of the Red Planet turned into dusty tracks on alien soil

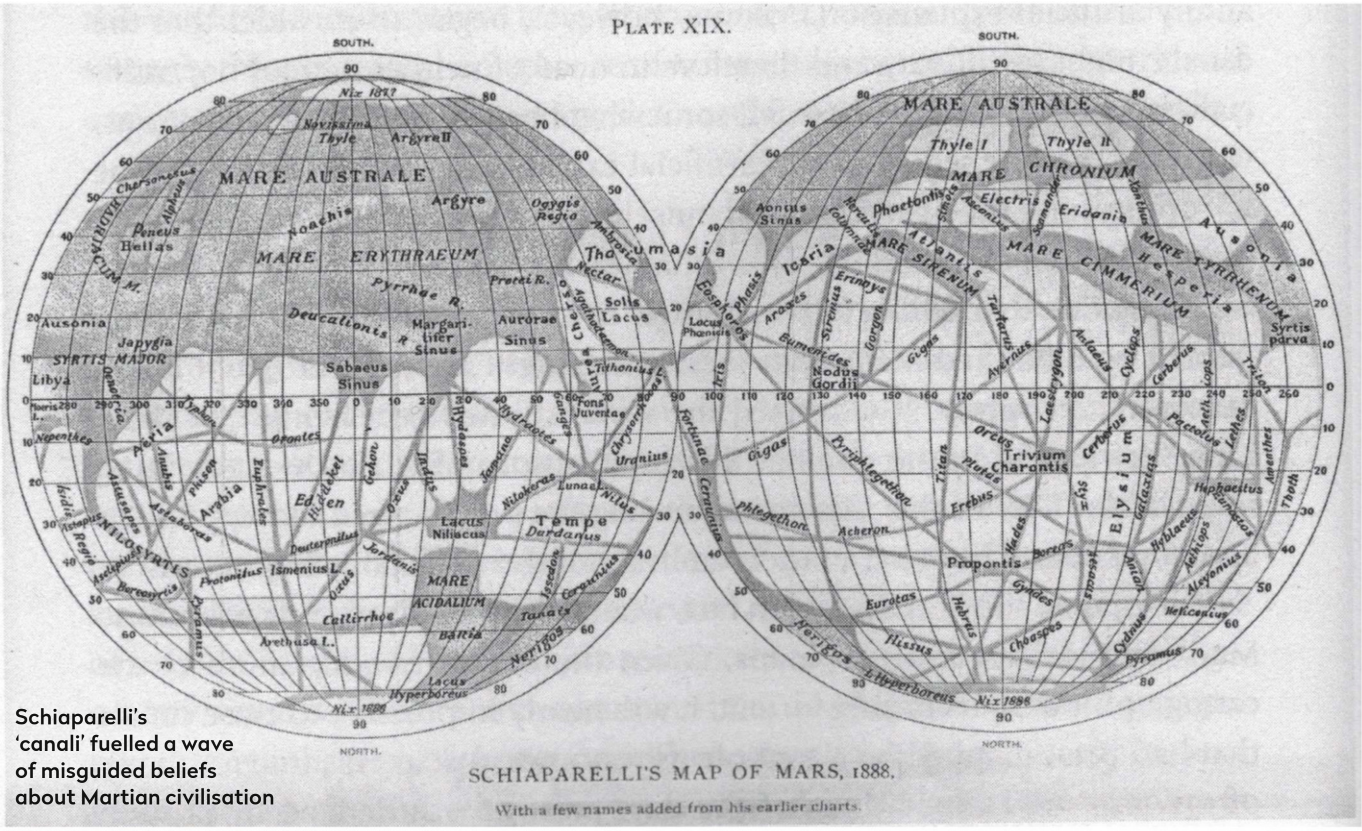


PLATE XIX.
SOUTH
NORTH
MARE AUSTRALE
MARE ERYTHRAEUM
Noachis
Argyre
Deucalionis R.
Pyrrhae R.
Sabaeus Sinus
Margaritifer Sinus
Aurorae Sinus
Solis Lacus
Ausonia
SYRTIS MAJOR
Libya
Hellas
Arabia
Eden
MARE ACIDALIUM
Tempe
MARE SIRENUM
MARE CIMMERIUM
MARE CHRONIUM
Elysium
Trivium Charontis
Propontis
MARE TYRRHENUM
Syrtis parva
SCHIAPARELLI'S MAP OF MARS, 1888.
With a few names added from his earlier charts.

Schiaparelli's 'canali' fuelled a wave of misguided beliefs about Martian civilisation

▶ Life on Mars has long sat at the forefront of human imagination. Early ideas regarded the Red Planet as little more than a volcanic wasteland. But in the 19th century, it adopted a new persona: a utopia, with 'Martians' exhibiting character traits of decadence and enlightened intelligence. One story even imagined them aging backwards, like otherworldly Benjamin Buttons.

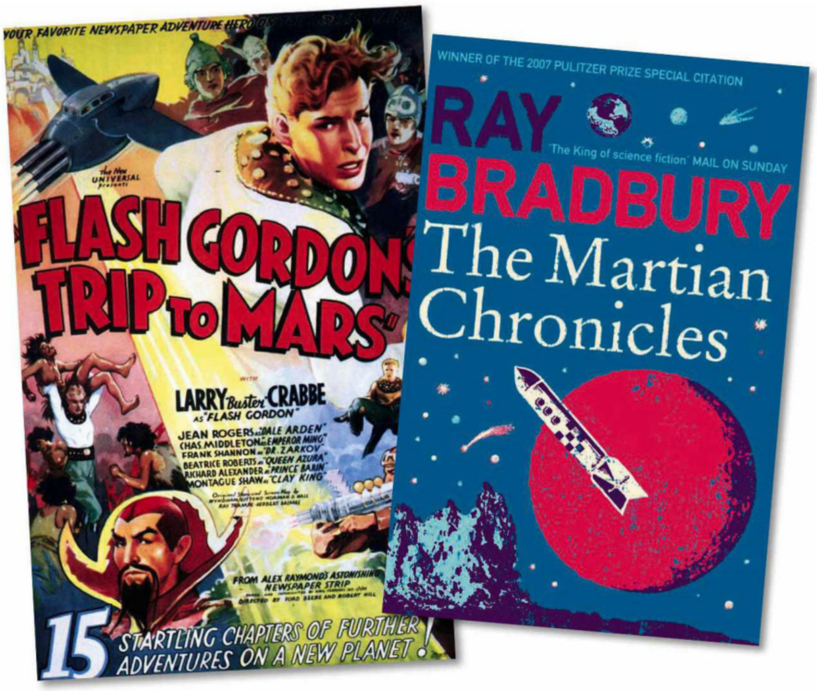
Canals and dead ends

Early astronomers stared for hours through telescope eyepieces at Mars's fuzzy red blob, then sketched what they saw. In 1877, Italian astronomer Giovanni Schiaparelli observed odd linear markings he called 'canali' – channels – later mistranslated as 'canals' and thereby suggesting, to English speakers anyway, there might be intelligent life on the Red Planet. American astronomer Percival Lowell believed these structures to be waterways built by advanced civilisations to irrigate their dying, desiccated planet. Lowell's writings caused a sensation, but as improved telescopes revealed Mars in finer detail, it became clear his imagined canals were neither irrigation channels nor linear rows of vegetation, but a case of 'pareidolia': the psychological trait of seeing meaningful images in otherwise random patterns.

Still, the question of life remained open. In the first half of the 20th century, Mars became a motif to project humanity's hopes and fears. As revolution gripped tsarist Russia, the Red Planet emerged in literature as a setting for class struggles and socialist utopias. And when two global conflicts consumed millions of human lives, 'Martians' morphed into bellicose, destructive figures in pulp-fiction comics.

But science soon proved modern Mars could not harbour complex life. Science-fiction writers switched gears, regaling their readers with tales of ruinous, extinct civilisations, doubtless inspired by Europe's shattered state post-1945. On the eve of the Space Age, they wrote of more rudimentary lichens and tumbleweeds. Mars's waterless aridity inspired novels of colonisation, notably Ray Bradbury's *The Martian Chronicles* (1950).

In 1965, America's Mariner 4 became the first space probe to reach Mars, revealing an atmosphere of 95 per cent carbon dioxide that's 100 times thinner and substantially colder than ours. The Soviet Mars 2 probe became the first to impact on Mars, in 1971, and showed the planet's water-vapour content is 5,000 times lower than our atmosphere, with surface pressures of 0.6 kPa (compared to 101.3 kPa on Earth) and mean temperatures of –63°C (–82°F). That indicated liquid water couldn't exist on the surface. And with no global magnetic field, any Martian life was perilously vulnerable to galactic cosmic rays and solar ultraviolet radiation. If life

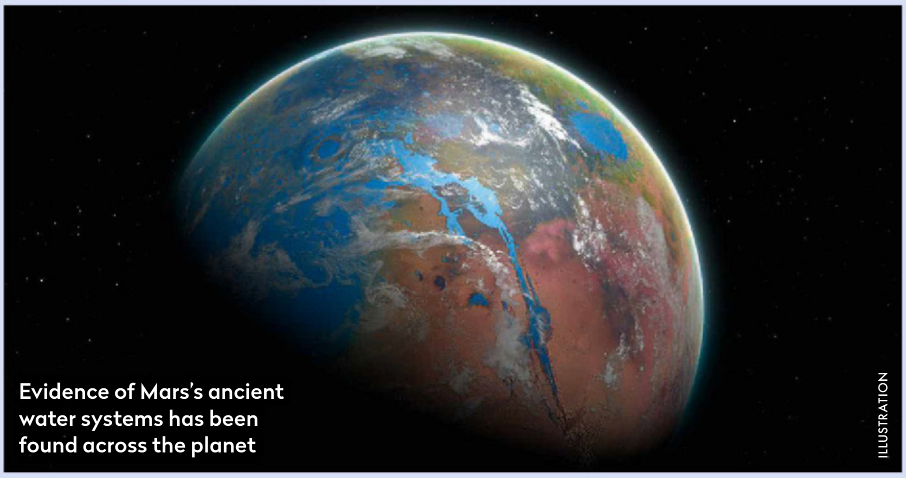

YOUR FAVORITE NEWSPAPER ADVENTURE HERO
The New UNIVERSAL presents
FLASH GORDON'S TRIP TO MARS
LARRY "Buster" CRABBE as "FLASH GORDON"
JEAN ROGERS as DALE ARDEN
CHAS MIDDLETON as EMPEROR MING
FRANK SHANNON as DR. ZARKOV
BEATRICE ROBERTS as QUEEN AZURA
RICHARD ALEXANDER as PRINCE BARIN
MONTAGUE SHAW as CLAY KING
FROM ALEX RAYMOND'S ASTONISHING NEWSPAPER STRIP
15 STARTLING CHAPTERS OF FURTHER ADVENTURES ON A NEW PLANET!
WINNER OF THE 2007 PULITZER PRIZE SPECIAL CITATION
RAY BRADBURY
'The King of science fiction' MAIL ON SUNDAY
The Martian Chronicles

▲ Popular depictions of Mars, reflecting interwar tensions (1938, left) and coloniser anxiety (1950, right)

ARCHIVE PL/ALAMY STOCK PHOTO, HARPERFICTION, MARK GARLICK/SCIENCE PHOTO LIBRARY/GETTY, NASA/JPL

Location, location, location

If life did exist on Mars, these five regions are our best bet of finding proof



Evidence of Mars's ancient water systems has been found across the planet

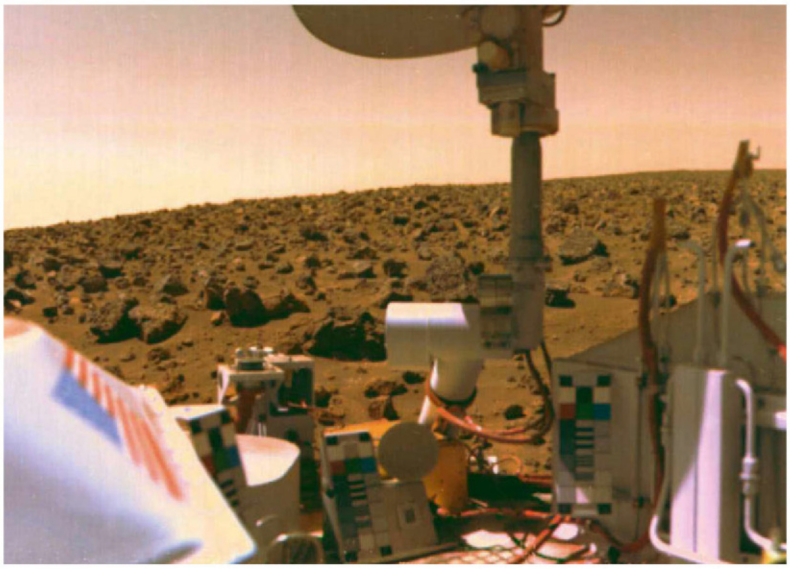
ILLUSTRATION

Measuring 154km (96 miles) wide, **Gale crater**, which NASA's Curiosity rover has been exploring since 2012, may have been a freshwater lake with vigorously flowing water 3.8 billion years ago. Its environmental conditions included neutral pH levels, low salinity and minerals usable by microorganisms.

Since 2021, Perseverance rover has investigated **Jezero crater**, a clay-rich area with an ancient lake up to 250 metres (820ft) deep. Conditions recorded at Jezero's Wildcat Ridge show it might once have been habitable. In 2024, Perseverance found leopard-like 'spots' on a reddish rock called Cheyava Falls that may have hosted microbial life.

The 4,000km (2,500-mile) canyon **Valles Marineris** may have contained a number of ancient lakes, with minerals present that only form in the presence of water. Some lakes could have been 0.8km (0.5 miles) deep, water volumes comparable to the Caspian Sea, and environmental conditions suitable for life.

An ancient lake may once have filled **Hellas basin**, the lowest point on Mars, and the area may have had geothermal sources of heat. If so, microbial life could have had more than enough time to develop. **Eridania crater** exhibits magnesium-rich clays and opaline silicas, consistent with the presence of an ancient lake. NASA's Mars Reconnaissance Orbiter found evidence of hydrothermal seafloor deposits in the crater, suggesting hydrothermal vents pumped mineral-laden water into the lake, possibly facilitating conditions suitable for life.



▲ **Viking 2's view of Utopia Planitia, 1976 – the landers found no clear evidence of life**

ever thrived on Mars, it must have existed in smaller, simpler forms.

Later missions offered more hopeful insights. In 1971, NASA's Mariner 9 hinted that ancient Mars was more clement than the planet's present-day incarnation. But NASA's two Viking landers that alighted on the surface at Chryse Planitia and Utopia Planitia in 1976 found no organic molecules. Their searches for life proved inconclusive.

Since the 1990s, multiple robotic orbiters, landers and rovers from the United States, Russia, Europe, China, India and the United Arab Emirates have been deployed to significant locations on Mars that may once have hosted flowing water and, by extension, perhaps also the 'biosignatures' of life. Liquid water being a key condition for life as we know it, exploring signs of ancient water in Mars's uninhabited present has shed new light on a potentially habitable past.

Hints of a watery past

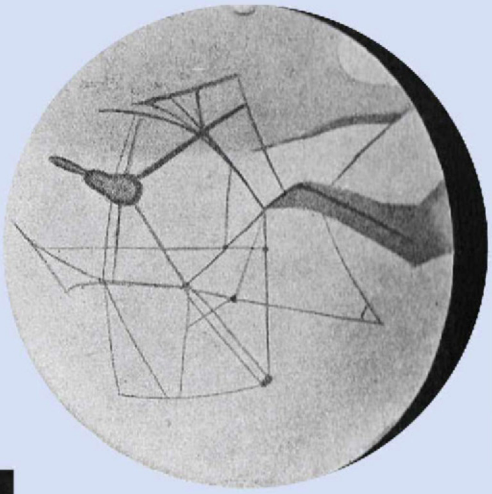
As early as Mariner 9, features that were strikingly reminiscent of streambeds were found. The Viking spacecraft identified deep river valleys, eroded grooves in bedrock and hints of torrential ancient rainfall. In 2012 at Gale crater, NASA's Curiosity rover detected unambiguous sediments left by vigorous flowing water that might once have been ankle- or waist-deep.

Traces of ancient lakes were also discovered. Gale crater may have been a freshwater lake some 3.8 billion years ago. Hundreds of 'closed-basin' lakes equal in volume to the Caspian Sea, Black Sea and Russia's Lake Baikal have been found – some formed by precipitation, others by groundwater; a handful form 'chains' 4,500km (2,800 miles) long, with drainage channels similar to the Missouri–Mississippi Rivers.

Some lakes could have been up to 200–250 metres (650–800ft) deep, their putative shorelines revealed in weathered 'benches' and scarps. Water might once have flooded Holden crater at rates 5–10 times faster than the Mississippi River's discharge. One lake ▶

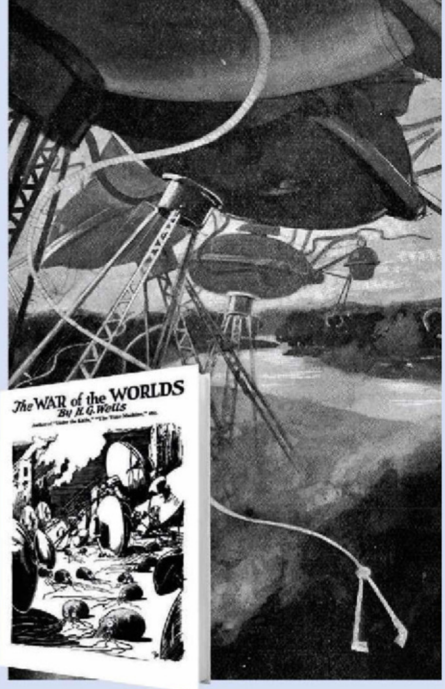
Martian myths

Strange faces, canal systems and Earth invaders: five fantastical visions of Mars that exist only in our imagination



1. Lowell's canals

Percival Lowell and others interpreted strange linear markings on Mars as canals engineered by sentient Martians. Future observations disproved this as an optical illusion, but author CS Lewis said the canals became "part of the popular tradition". Mariner 4's fly-by in 1965 conclusively disproved their existence.

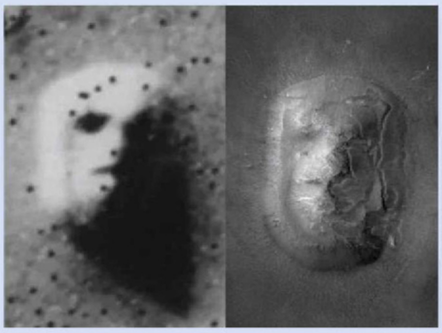

The WAR of the WORLDS
By H.G. Wells

2. *War of the Worlds*

HG Wells's 1898 *War of the Worlds* presented Martians with an inhuman appearance. Inspired by 19th-century British colonialism and its devastating effect upon Aboriginal Tasmanians, Wells inverted the idea of aliens from beneficent beings of higher intelligence into fearsome, warlike creatures.

3. Orson Welles's radio broadcast

In 1938, Orson Welles narrated an adaptation of *War of the Worlds* for CBS. Presented as a simulated radio broadcast, with newsflashes and eyewitness accounts, its description of a Martian invasion won 23-year-old Welles fame as an innovative storyteller. It also became notorious due to the panic it induced among listeners.



4. The Face on Mars

First imaged by the Viking 1 orbiter in 1976, the Face on Mars is in the Cydonia region of Mars's northern hemisphere. At around 2km (1.2 miles) long, this mesa resembles a human face when viewed under certain conditions. But the 'face' is a mere trick of light and shadow, appearing as a natural rock formation when seen from other angles.

5. Mars gremlins

In 60 years of robotic exploration of Mars, half of all missions have ended badly due to launch failures, communication losses, explosions, software bugs or crash landings. These were colloquially attributed to 'Mars gremlins', honouring the mischievous folklore figures who delight in causing malfunctions in machinery.

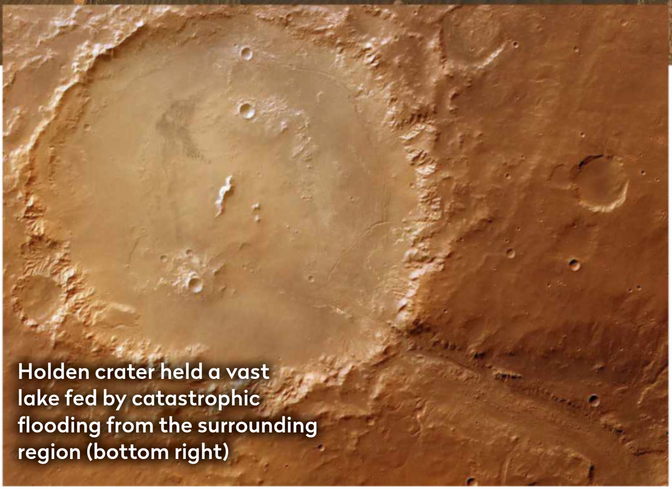
▶ possibly held nine times more water than all of North America's Great Lakes put together.

River deltas and long sinuous gullies, knobbly material on crater floors and fan-like deposits hint at fluctuating water levels over time. Clays that need long-term water exposure to form have been found. So too have minerals like smectite, kaolinite, prehnite, jarosite, goethite and haematite, all of which only form in water's presence. Most recently, NASA's Perseverance rover has been exploring Jezero crater – an ancient lake – uncovering layered rocks and minerals that form only in the presence of liquid water.

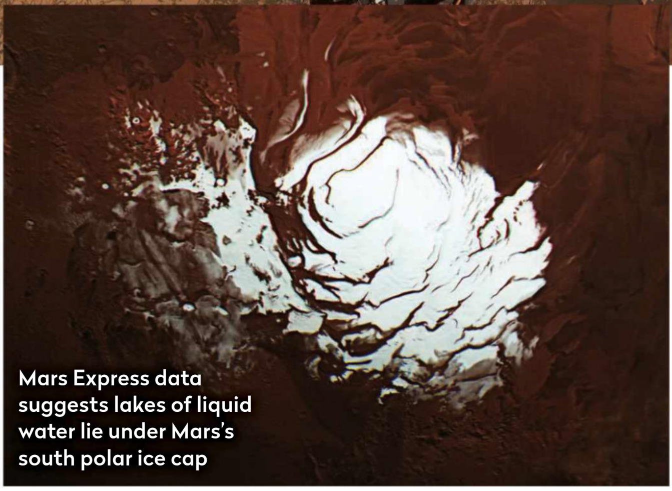
All this suggests that Mars could once have been hospitable to life. Its carbon dioxide atmosphere may have been far thicker (maybe as thick as ours), enabling higher surface temperatures and allowing lakes up to 20km (12 miles) wide, and perhaps a giant ocean rivalling the Arctic Ocean, to have endured for millions of years.

Such habitable conditions were thanks to a 25 per cent lower energy output from the young Sun and a greenhouse effect, induced by the thick carbon dioxide atmosphere, insulating and warming the surface. Over time, Mars's magnetic field decayed

Curiosity found signs that ancient Mars once had water and the right chemical ingredients for life



Holden crater held a vast lake fed by catastrophic flooding from the surrounding region (bottom right)



Mars Express data suggests lakes of liquid water lie under Mars's south polar ice cap

Ben Evans is a science writer and author of several books on spaceflight

and most of its atmosphere was stripped away by meteoritic bombardment and the solar wind.

Far from friendly

That stripping away of the atmosphere precipitated the planet's loss of habitability. Remnant water that didn't escape into space likely resides in the atmosphere, deep underground or in polar ice caps. NASA's InSight probe hinted at liquid water 10–20km (6–12 miles) beneath the surface. Europe's Mars Express pointed to possible subglacial lakes under the south polar cap: the first evidence of stable bodies of liquid water on Mars.

While water is a prerequisite for habitability, it is not sufficient on its own. Other environmental factors – such as the availability of nutrients, a source of energy, a suitable atmospheric composition, survivable temperatures and pressures, low surface toxicity, and protection from galactic cosmic rays and solar ultraviolet radiation – must also be met.

Ground-based simulations indicate that if multiples of these 'lethal factors' are combined, the likelihood of finding life – even in supposedly 'habitable' areas of the planet – plummets. No full-scale simulations of Martian surface conditions have been conducted that include all potential 'biocidal' elements.

If life ever arose on Mars, it is unlikely to have been complex, multicellular organisms and probably took shape at a microbial level in liquids or sediments. In 2012, it was suggested that 'extremophile' lichens could exist in simulated Martian environments. 'Halotolerant' organisms, life forms capable of enduring conditions of complete darkness, low nutrient levels, high pressures and isolation from the atmosphere, may thrive in Mars's subglacial lakes.

Even the hardiest microorganisms couldn't survive on Mars's surface and would quickly succumb to high radiation levels. Yet radiation modelling suggests that microorganisms buried deeper beneath the surface could persist for 90,000 to 500,000 years. Survival might also be possible near geothermal hotspots, volcanic lakes or acidic hot springs.

Despite teasing clues of past and present water activity, no conclusive evidence has been found for life on Mars. And with the likelihood that astronauts might set foot on the Red Planet within the next two decades, it's possible the first 'life' on Mars, the first true 'Martians', will not be fearsome tripods, little green men or even microscopic bacteria. Instead, the first life on Mars might turn out to be… us.

ILLUSTRATION

Though seemingly once awash with water, evidence of life remains elusive – at least until we arrive

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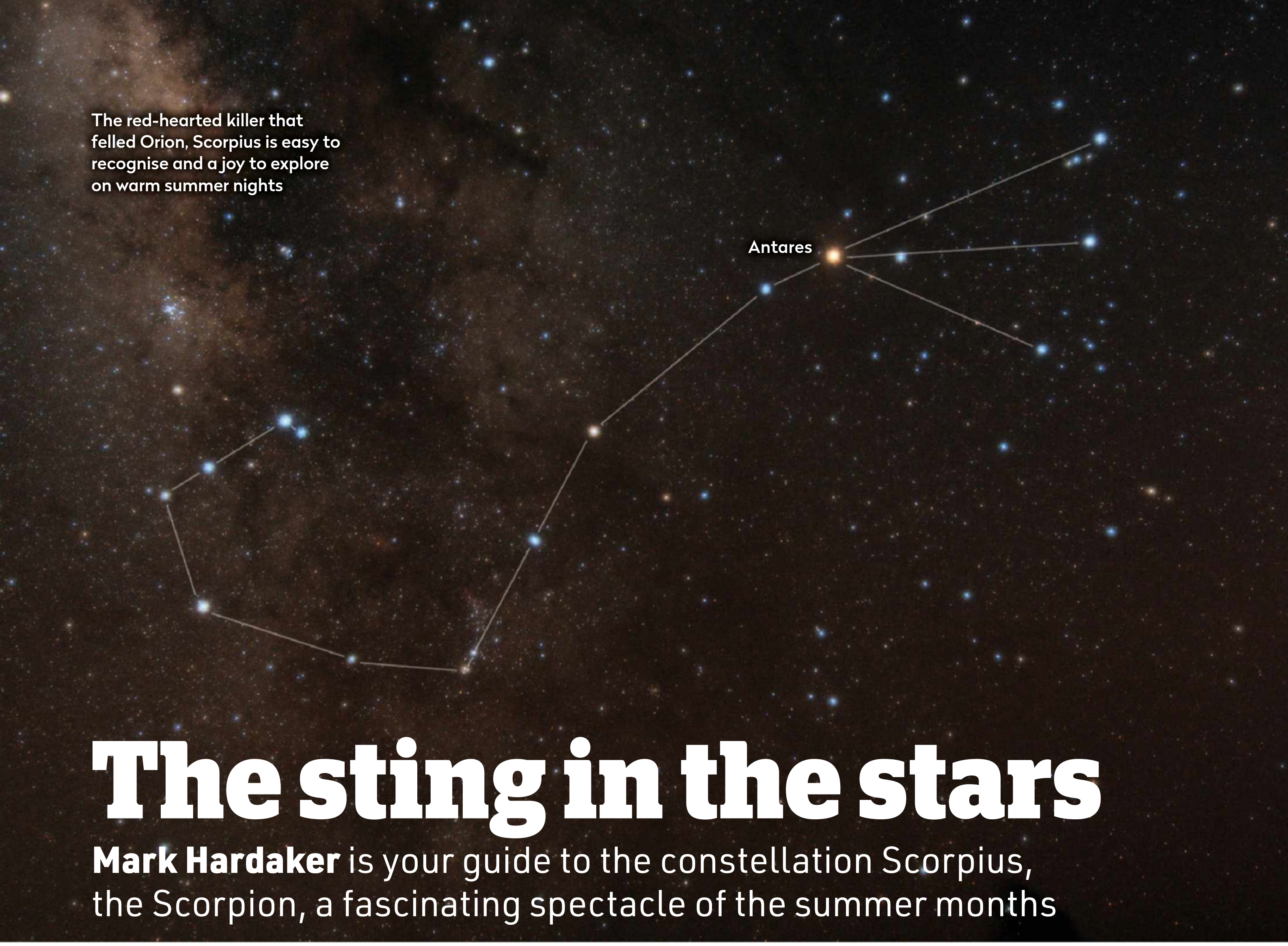
The sting in the stars

Mark Hardaker is your guide to the constellation Scorpius, the Scorpion, a fascinating spectacle of the summer months



The red-hearted killer that felled Orion, Scorpius is easy to recognise and a joy to explore on warm summer nights

Scorpius is one of the most distinctive and easily recognised constellations in the night sky, and has captivated the imaginations of stargazers for millennia. It's renowned not only for its red, bright heart, the star Antares, but also for its ancient mythological roots, stunning deep-sky objects and a rather contentious historical relationship with its neighbour Libra.

It's a constellation steeped in myth, most notably Greek mythology, representing the scorpion sent by the Earth goddess Gaia (or sometimes Artemis or Hera, depending on which version you follow) to kill the great hunter Orion. According to the story, Orion boasted that he would slay every animal on Earth, angering the gods. To punish his conceit, a giant scorpion was sent to confront him and sting the hunter to death. The gods placed both Orion and Scorpius in the sky, but on opposite sides – ensuring that they would never appear together. When Scorpius rises in the east in summer, Orion sets in the west, and vice versa, symbolising their ongoing cosmic chase.

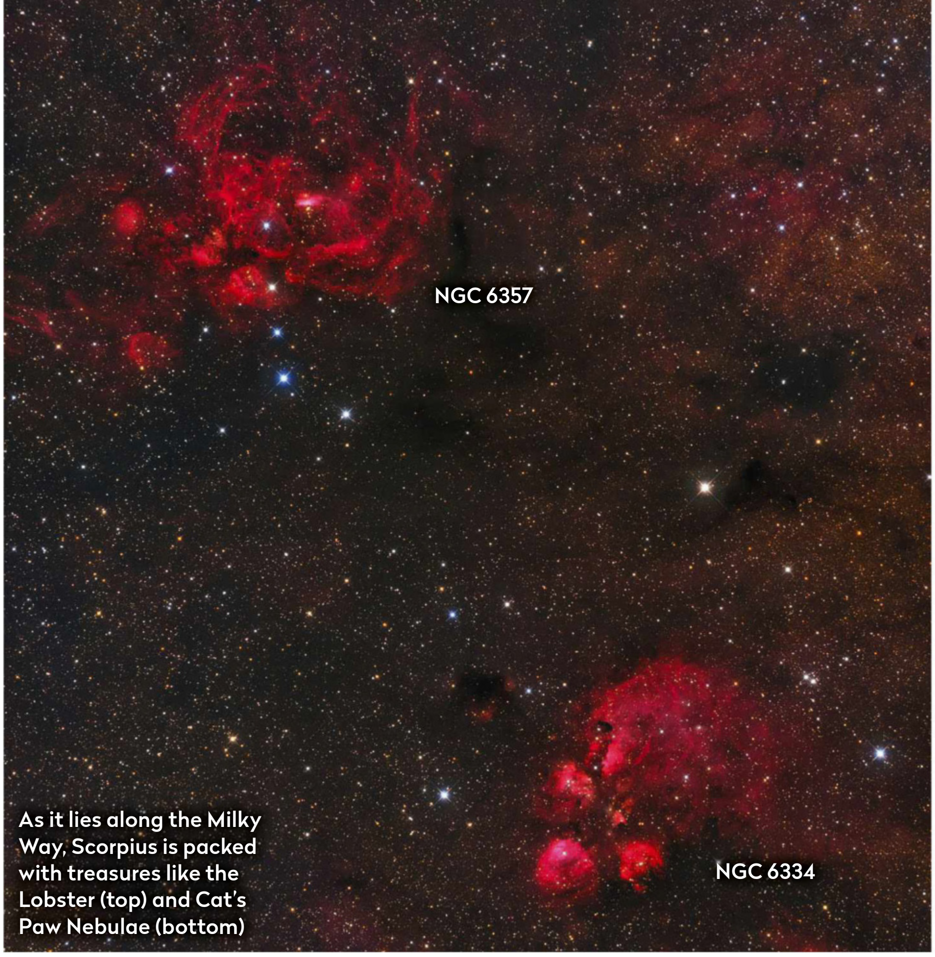
Observing Scorpius

Due to its southerly declination, Scorpius is best seen from the Southern Hemisphere, where it reaches its highest point in the sky in winter; July nights find the constellation almost overhead. The Northern Hemisphere doesn't get quite as good a view, with Scorpius appearing low in the south over the summer months, but if you can locate it, it's well worth the effort. From North American latitudes (40° north), the entire scorpion, including its tail, can be seen. From the British Isles, only the head and heart are visible, the tail never rising above the horizon.

One of the 48 classical constellations listed by the second-century Greek astronomer Claudius Ptolemy, it remains one of the 88 modern constellations recognised by the International Astronomical Union. Scorpius is notable for its curved formation, which closely resembles the traditional depiction of a

▼ **Scorpius's lovely Butterfly Cluster. Can you spot its wings and antennae?**

BERNHARD HUBL/CCDGUIDE.COM X 2, GERALD RHEMANN/CCDGUIDE.COM, STELLARIUM



As it lies along the Milky Way, Scorpius is packed with treasures like the Lobster (top) and Cat's Paw Nebulae (bottom)

scorpion with tail and stinger. Its distinctive shape and proximity to the Milky Way make it a favourite among amateur astronomers.

The most prominent star in Scorpius is Antares, a red supergiant and one of the brightest stars in the night sky. 'Antares' in Greek means 'rival of Mars', the star's reddish hue meaning that it often resembles the Red Planet in the sky. Antares lies about 550 lightyears from Earth and shines with a luminosity 75,000 times that of our Sun.

Although Scorpius is officially a zodiac constellation, the Sun spends little time there, transiting in only six days, towards the end of November each year. In fact, the neighbouring constellation of Ophiuchus, the Serpent Bearer, is home to the Sun for a considerably longer period, at approximately 19 days.

Deep-sky delights

Scorpius lies along the plane of the Milky Way, making it rich in deep-sky objects. Several star clusters and nebulae are visible within its boundaries.

Messier 4 (M4) is a large globular cluster just west of Antares. At about 7,200 lightyears away, it's one of the closest globular clusters to Earth, and through binoculars or a telescope you'll see a sparkling swarm of ancient stars. Heading further south, Messier 6, the Butterfly Cluster, is an open star cluster that gets its name from its symmetrical, butterfly-like shape. It lies about 1,600 lightyears away and is composed of young, hot stars.

Trickier to see, especially from northerly latitudes, is Messier 7 or Ptolemy's Cluster (Ptolemy catalogued it in the second century). M7 is one of the brightest open clusters and is visible to the naked eye under dark skies. It's also the most southerly Messier object, and so a challenge to locate the further north you are.

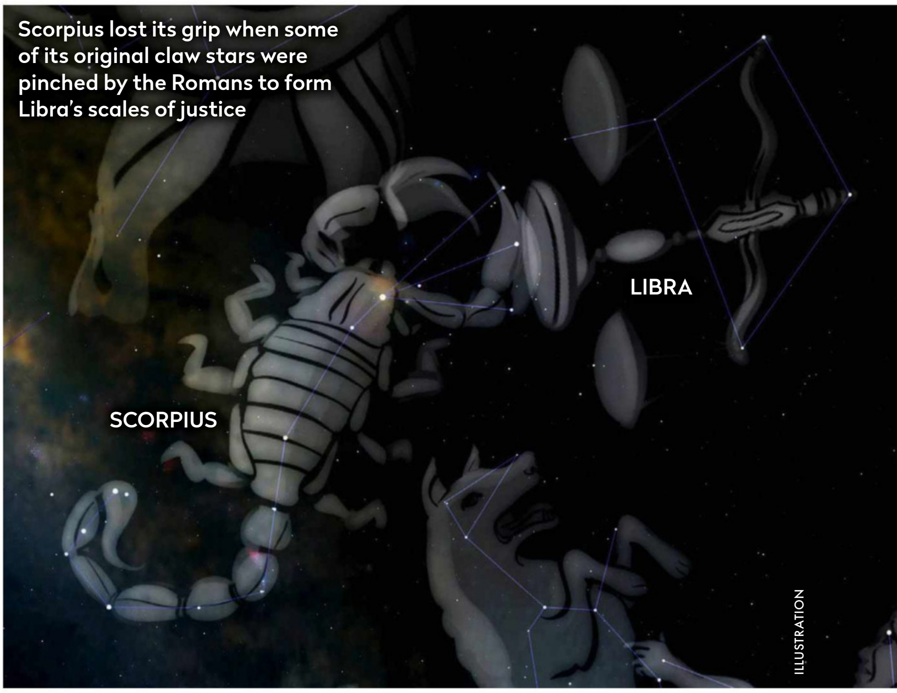
Scorpius is also home to the Cat's Paw Nebula (NGC 6334) and the Lobster Nebula (NGC 6357). These are emission nebulae: enormous stellar nurseries where new stars are being born. The Southern Hemisphere offers the best views of these two objects.

Stolen claws

An intriguing aspect of Scorpius lies in its historical connection with neighbouring constellation Libra. In ancient times, the stars that now form Libra were considered part of Scorpius: the scorpion's claws, in fact. And this is evident in the names of several of Libra's stars. For example, Zubenelgenubi (Alpha Librae) means 'the southern claw' in Arabic, while Zubeneschamali (Beta Librae) is 'the northern claw'.

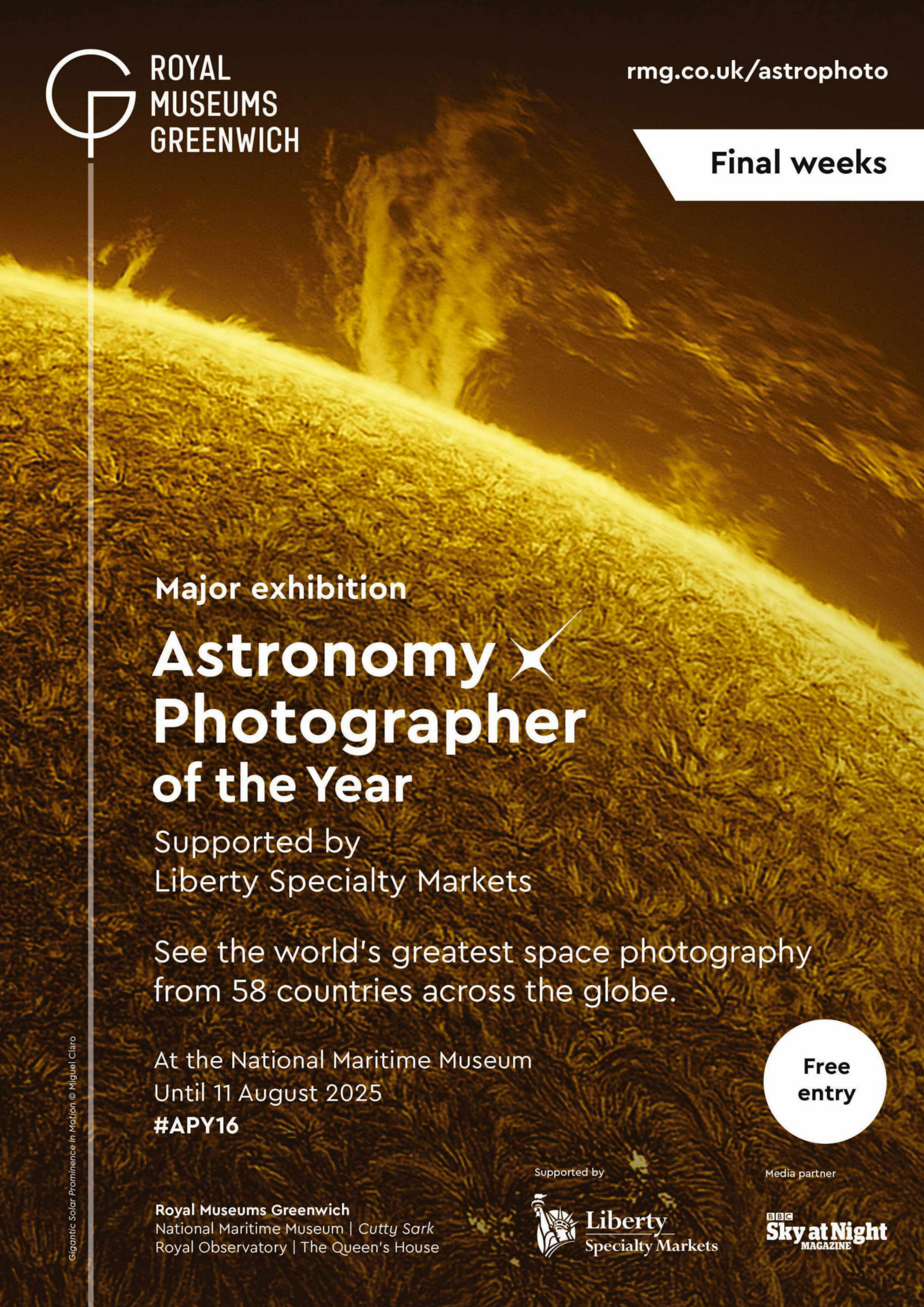
These names reflect the time when the claws of Scorpius stretched across what is now the constellation Libra. It wasn't until Roman times that these stars were redefined as part of a separate constellation symbolising the scales of justice. This reclassification is a fascinating example of how human culture and astronomical knowledge evolve in tandem. While the mythological scorpion lost its claws in the formal star charts, the stars' names still preserve the memory of when they formed part of the menacing creature in the summer sky.

Mark Hardaker is an amateur astronomer, writer and communicator



Scorpius lost its grip when some of its original claw stars were pinched by the Romans to form Libra's scales of justice

ILLUSTRATION



Gigantic Solar Prominence in Motion © Miguel Claro

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BBC Sky at Night MAGAZINE

The Sky Guide

AUGUST 2025

DAZZLING DAWN DUO

Brilliant Jupiter and Venus have a very close conjunction, the pair doing a cosmic shuffle in the early morning sky all month long

TITAN VANISHES

Watch Saturn's moon disappear into shadow

STAR SAFARI

Track down deep-sky and binocular targets around Camelopardalis

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- ✦ Early morning Uranus
- ✦ Minor planet 2 Pallas at opposition
- ✦ Variable star SS Cygni
- ✦ Perseids peak
- ✦ Plato's Hook

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

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AUGUST HIGHLIGHTS

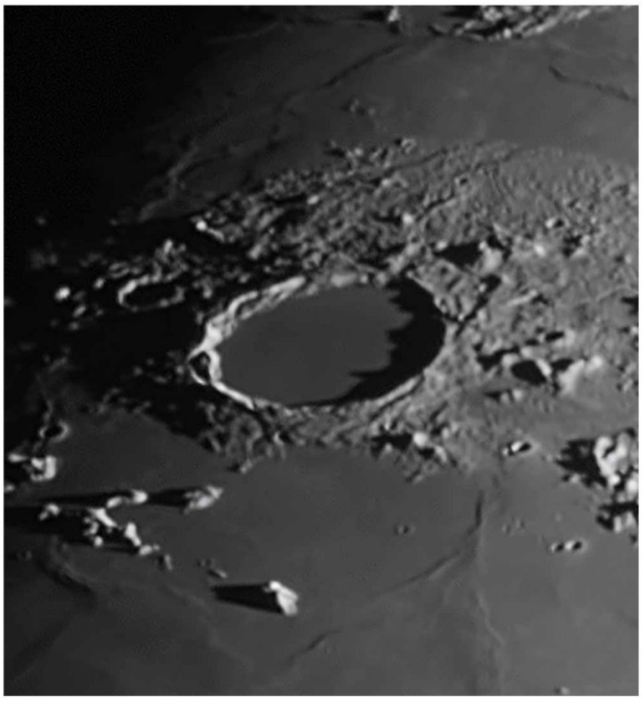
Your guide to the night sky this month

Friday
1

Our Moonwatch target (see page 52), the walled plain Flammarion, is well placed this evening and tomorrow evening. You can also catch it on the waning Moon on the morning of 16 August.

Saturday ▶
2

This evening, take a look into the crater Plato, where a shadow is formed on its floor from a rim peak. The shadow has been described as appearing curved in the past, forming the clair-obscur effect known as Plato's Hook. See page 47 for more details.



◀ Friday
8

Catch the full Moon rising around 21:30 BST (20:30 UT) and see whether you experience the Moon illusion, which makes it look huge. In reality, it's no larger than at any other time.

Tuesday ▶
12

The Perseid meteor shower peaks tonight. See page 76 for how to capture it in moonlight.

Venus and Jupiter reach ecliptic conjunction in the early morning sky. See page 46.

Saturday
16

If you can locate the last quarter Moon in daylight, around 10:30 BST (09:30 UT) look out for the bright line made by the Straight Wall, Rupes Recta. At this phase, it forms the blade of an effect known as The Cutlass.

◀ Tuesday
19

Mercury reaches greatest western elongation, visible in the morning sky from about an hour before sunrise. Mercury currently shines at mag. +0.1.

Wednesday
20

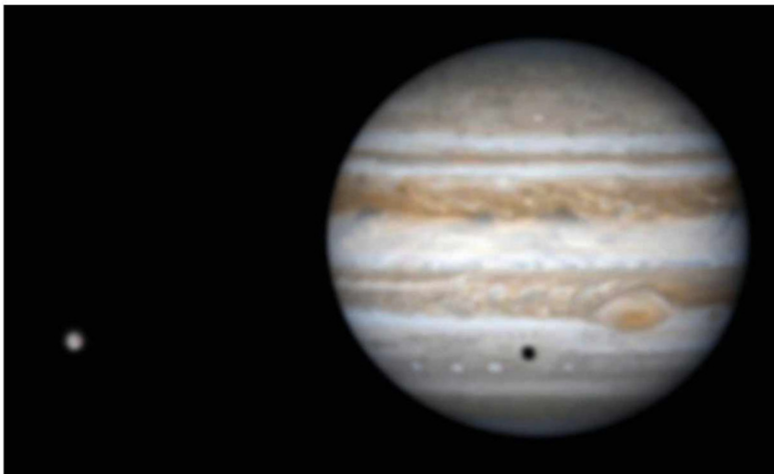
This morning, a 10%-lit waning crescent Moon sits just north of the mid-point of a line between mag. –3.9 Venus and mag. –1.8 Jupiter. Spot them together from around 04:00 BST (03:00 UT).

Thursday
21

From west to east, mag. –1.8 Jupiter, –3.9 Venus and –0.2 Mercury line up over the east-northeast horizon, from around 04:30 BST (03:30 UT). A 4%-lit crescent Moon appears between Venus and Mercury too.

Family stargazing

The meeting between Jupiter and Venus in the early morning sky is a great challenge for youngsters to observe (see page 46). They can start observing the approach to conjunction from the start of August, with the closest meeting occurring on 12 August. Of course, after this it's also possible to watch them separate again. As an observing challenge, ask them to measure the separation distance, using the width of their little finger at arm's length as the measuring unit. Record the number of 'little finger widths', along with the date and time. **www.bbc.co.uk/cbeebies/shows/stargazing**



PETE LAWRENCE X 8

Sunday

3

An early morning look towards the east-northeast will show mag. –3.9 Venus slightly less than 10° west of mag. –1.8 Jupiter.

Monday

4

Mag. +0.5 Saturn is currently close to mag. +7.8 Neptune, the two planets appearing 1.1° apart in the morning sky, with Neptune due north of Saturn.

Tuesday

5

Catch the bright peak of Mons Herodotus this evening, forming a lunar clair-obscur effect known as the Star-Tip Mountain.

Sunday

10

The minor planet 2 Pallas is at opposition, shining at mag. +9.4 against the stars of Delphinus.

Monday ▶

11

Brilliant Venus and Jupiter are just 1.4° apart in this morning's sky.

◀ Sunday

17

As the Moon slips out of the way, this is a good time to try this month's Deep-Sky Tour (see page 56). For August, we're looking at objects within the faint constellation Camelopardalis, home of the asterism known as Kemble's Cascade.

Tuesday

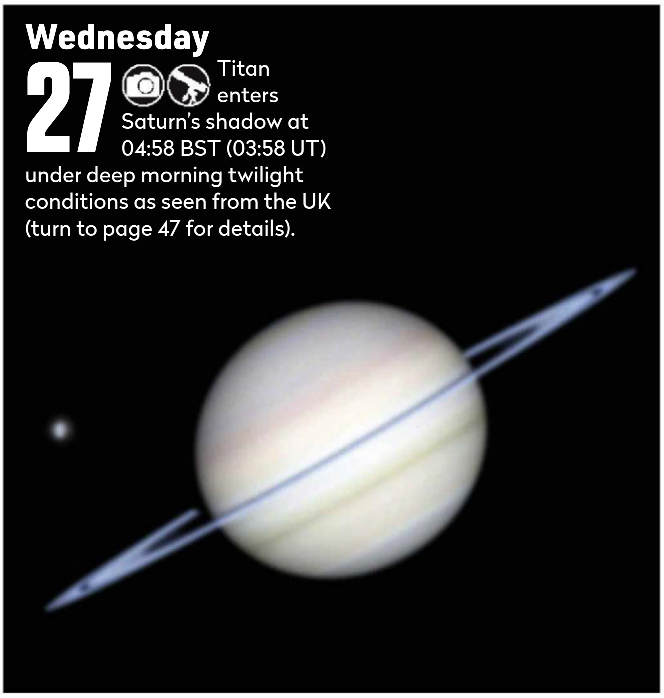
26

There's a tricky conjunction between mag. +1.6 Mars and a 12%-lit waxing crescent Moon just after sunset today. The Moon will be very low above the west-southwest horizon.

Wednesday

27

Titan enters Saturn's shadow at 04:58 BST (03:58 UT) under deep morning twilight conditions as seen from the UK (turn to page 47 for details).



◀ Sunday

31

A third chance to see our Moonwatch target, Flammarion, optimally lit (see page 52).

At 03:28–06:37 BST (02:28–05:37 UT), Ganymede's shadow can be seen transiting Jupiter's disc.

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

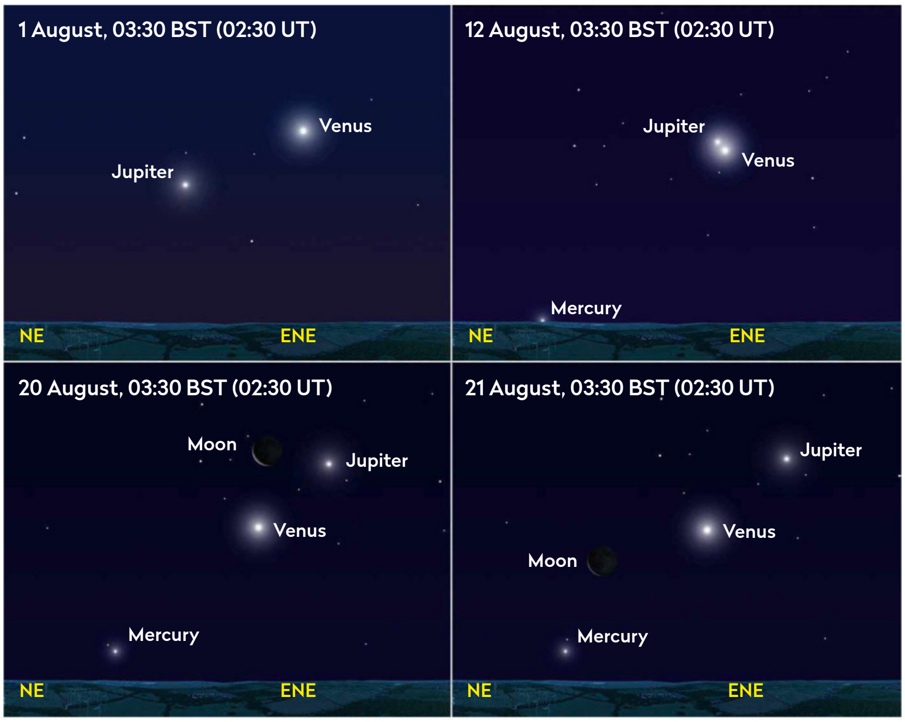
If you're new to astronomy, you'll find two essential reads on our website. Visit **bit.ly/stargazing-top-tips** to learn how to stargaze in 12 easy steps and **bit.ly/choose-first-telescope** for advice on choosing your first scope

THE BIG THREE The top sights to observe or image this month

DON'T MISS

Mercury, Venus and Jupiter

BEST TIME TO SEE: From 03:30 BST (02:30 UT) all month. Closest approach on 12 August


1 August, 03:30 BST (02:30 UT)
Venus
Jupiter
NE
ENE
12 August, 03:30 BST (02:30 UT)
Jupiter
Venus
Mercury
NE
ENE
20 August, 03:30 BST (02:30 UT)
Moon
Jupiter
Venus
Mercury
NE
ENE
21 August, 03:30 BST (02:30 UT)
Jupiter
Venus
Moon
Mercury
NE
ENE

▲ **Get up before the Sun this month and you'll catch Mercury, Venus, Jupiter and the waning crescent Moon putting on a spectacular show in the August morning sky**

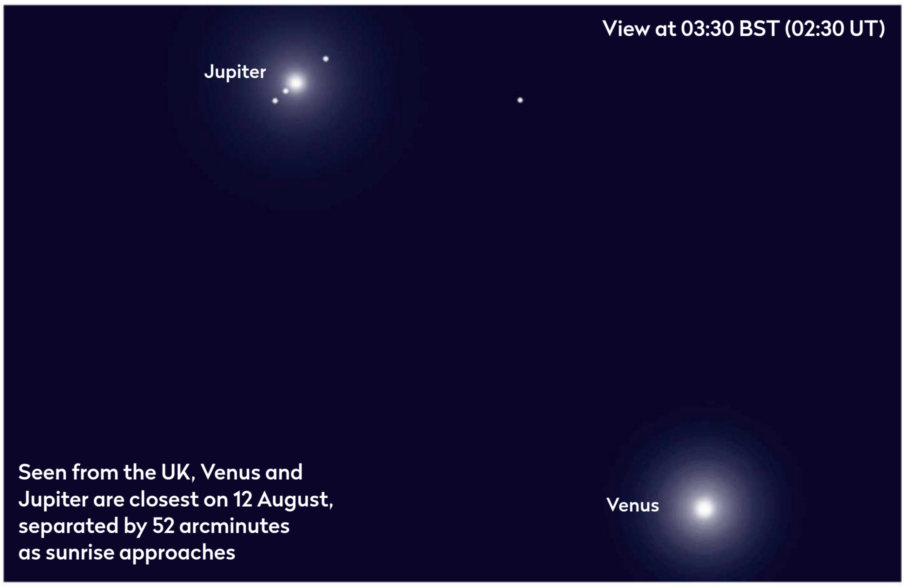
Venus is the brightest planet that can be seen from Earth. At its peak brightness, when 22% illuminated, Venus approaches mag. –5 – that's so bright that it can cast shadows, if conditions allow. Jupiter is bright too, able to reach mag. –2.94 under optimum conditions (coincidentally, that's the same maximum brightness as Mars). Mercury isn't far behind, able to attain a peak magnitude of –2.48.

Of course, catching all four near one another at peak brightness can't actually happen, as Jupiter and Mars need to be opposite the Sun, a position that Mercury and Venus can never attain. That's not to say that a meeting between some of these worlds isn't impressive – and this month, you'll have a chance to take a look and see for yourself. On 1 August, it's just mag. –3.9 Venus and mag. –1.8 Jupiter that appear together in the dawn twilight. They appear a little under 11° apart on this date, both being above the horizon just after 03:00 BST (02:00 UT), but you'll need to give them a bit more time to get to a decent altitude for viewing, say from around 04:00 BST (03:00 UT).

Over the course of the following mornings, the apparent gap between them closes due to Venus making a dash to the east, running under the stars that form the Gemini twin Castor's foot. Catch Venus early enough on 2 August, when the sky is still dark, and you might be able to see it 2.3° south of the open cluster M35. Binoculars will give the best view of this meeting.

On the morning of 7 August, the separation will be just 5°, Venus's eastward rush far greater than the slow eastward crawl currently exhibited by Jupiter. Mercury is around too, but stubbornly refuses to be seen on this date, being too far entrenched in the Sun's glare. By 10 August, Jupiter and Venus will appear a little over 2° apart, now a striking pair for those who get up early enough to see them. The closest approach occurs on the morning of 12 August, the planets being separated by 52 arcminutes. Telescopically, Venus is showing a 13-arcsecond disc, 78%-illuminated. Jupiter appears 33 arcseconds across.

After 12 August, the pair start to separate once again, but another element is now ready to come into play. Mercury is now brightening, appearing as a star-like dot in the morning twilight further to the east of the main pair. Between 19 and 22 August, the waxing crescent Moon skips along the line of planets, augmenting what is sure to be an already dynamic Solar System display.

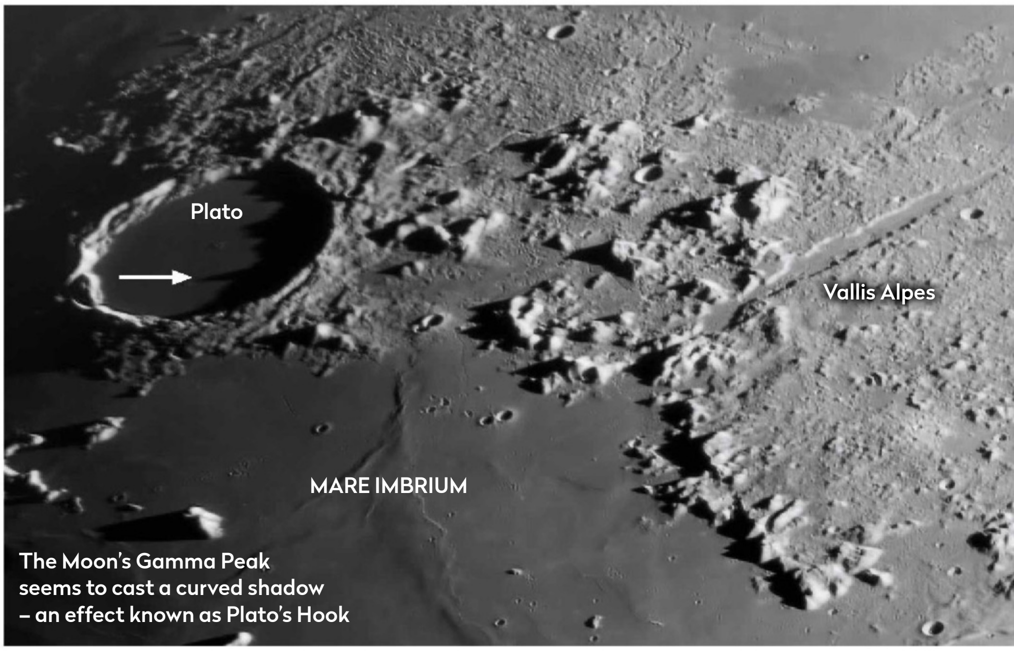


Seen from the UK, Venus and Jupiter are closest on 12 August, separated by 52 arcminutes as sunrise approaches

ALL PICTURES: PETE LAWRENCE

Plato's Hook

BEST TIME TO SEE: Evening of 2 August from 21:00 BST (20:00 UT)



The Moon's Gamma Peak seems to cast a curved shadow – an effect known as Plato's Hook

Plato is an iconic sight on the Earth-facing side of the Moon. Located at the northern edge of Mare Imbrium, this 100km crater lies within a bright highland fringe along the northern edge of the mare, its dark lava-flooded floor contrasting with its lighter surroundings.

Those with larger scopes or high-resolution imaging setups will see some of the small craterlets that interrupt what is otherwise a very flat floor, but good seeing and optimal illumination are required. The floor looks remarkably flat through smaller scopes, the perfect 'screen' for seeing a lunar curiosity this month: Plato's Hook.

Plato's rim is well formed, a circular wall around the dark floor. The vertical profile of the rim is, as you might expect, a little irregular. Along the eastern rim section, there's a peak which rises to around 3km above Plato's floor. Known as the Gamma Peak, this casts a sharp incisor-shaped shadow across the floor when the illumination is from the east – in other words, just after lunar dawn at Plato.

The curious element comes from the shape of the shadow. Some reports have suggested it has a curved appearance, hence the name Plato's Hook. Various explanations have been put forward for this phenomenon, but capturing the hook at the right time to image it isn't easy, due to a combination of Moon visibility, shadow timing and the weather.

If you want to see it for yourself, the shadow will be on view on 2 August. We'd recommend finding the Moon and viewing the region from around 21:00 BST (20:00 UT) on the evening of 2 August and monitoring the area for as long as you can. You will see the shadow appear, then shrink in size as the Sun gets higher in Plato's sky. Will it look curved though?

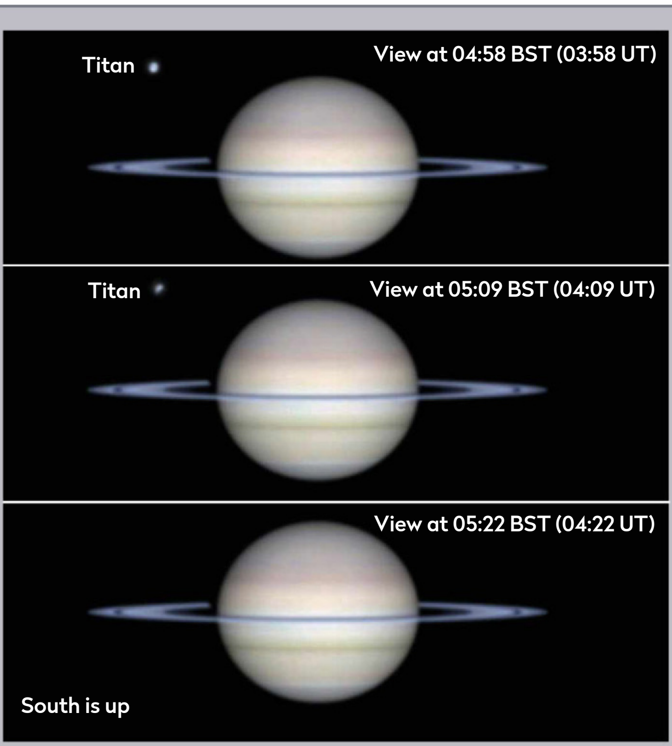
Titan eclipsed

BEST TIME TO SEE: 27 August, from 04:45 BST (03:45 UT)

Saturn remains almost edge-on as seen from Earth, and this continues to provide opportunities to see rare interactions between the planet and its largest moon, Titan. Up to now, these have been happening under less-than-optimal conditions, often with the sky quite bright. This has made what is already a challenging observation that bit harder still. Occurring nearly 16 days apart, the shift in timings towards darker sky conditions is slow, but it is improving.

On 27 August, Titan will be eclipsed by Saturn's shadow. The event begins at 04:58 BST (03:58 UT) under deep twilight conditions. If it's clear at this time, it's perfectly feasible to see mag. +8.4 Titan through even a small scope. We'd recommend starting to watch the moon a little earlier, say from 04:45 BST (04:45 UT), keeping an eye on it and getting used to the view.

Once it begins to enter Saturn's shadow, it takes Titan with its 0.8-arcsecond disc, around 24 minutes to fully disappear. The sky will be starting to get brighter as the last bit of Titan disappears from view, but this is still before sunrise, so there's a good chance it will be possible to see the whole event play out.


Titan
View at 04:58 BST (03:58 UT)
Titan
View at 05:09 BST (04:09 UT)
View at 05:22 BST (04:22 UT)
South is up

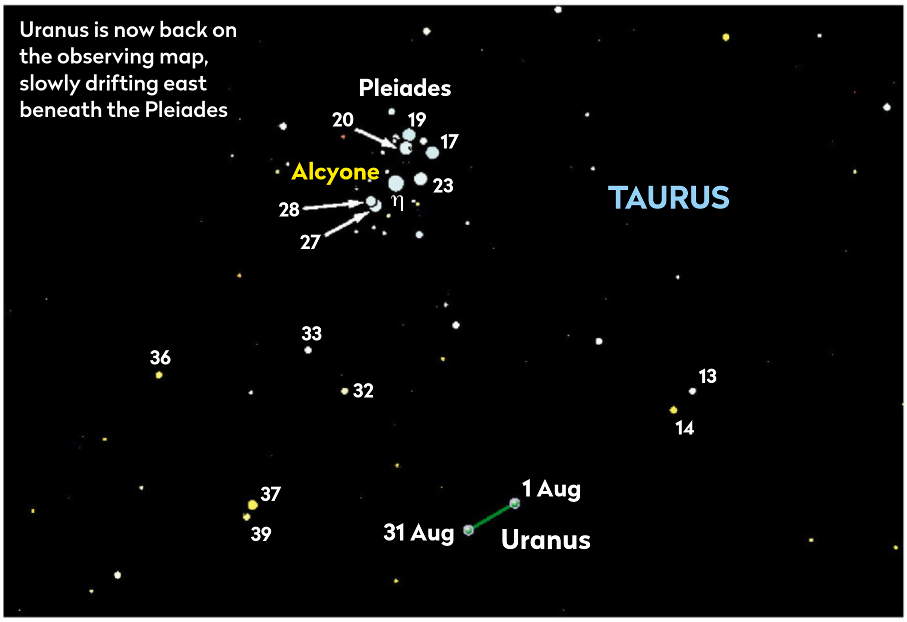
▲ **Titan is eclipsed by Saturn's shadow on the morning of 27 August**

THE PLANETS Our celestial neighbourhood in August

PICK OF THE MONTH

Uranus

Best time to see: 31 August, 04:00 BST (03:00 UT)
Altitude: 48°
Location: Taurus
Direction: Southeast
Features: Colour, subtle atmospheric banding, moons
Recommended equipment: 200mm or larger


Uranus is now back on the observing map, slowly drifting east beneath the Pleiades

Pleiades
20
19
17
Alcyone
23
28
η
27
TAURUS
33
36
32
13
14
1 Aug
37
39
31 Aug
Uranus

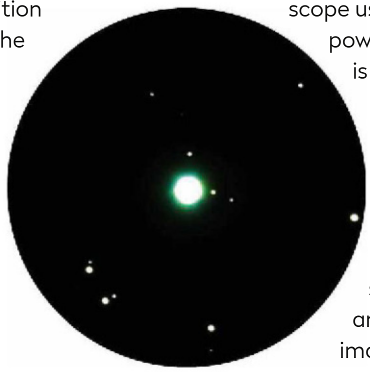
It's surprising how rapidly darkness expands in August, which is perfect timing for viewing the planet Uranus, as by the end of the month it's able to reach a decent altitude above the southeast horizon before the onset of dawn.

On 1 August, morning twilight truncates the observing window at around 02:20 BST (01:20 UT), this distant world only achieving a peak altitude of around 16° on this date. For many years, Uranus has been in stellar limbo on the Aries–Taurus border. While not particularly difficult to track down, it has lacked bright guiding stars over this period – something that may have put off casual observation.

Having drifted further east at a painfully slow rate, the planet is now well and truly within Taurus and much more conveniently located immediately to the south of the Pleiades open cluster. On 31 August, the planet's eastern drift will have moved it into a position 4.5° south-southeast of the centre of the Pleiades. As a consequence, any widefield image that includes the Pleiades, Aldebaran and the Hyades at this time will also include Uranus.

Through binoculars, Uranus looks just like a mag. +5.7 star. However, a small telescope makes the planet's green hue very apparent, with Uranus resembling a shining emerald under low-power views. Its disc is tiny at around 3 arcseconds across, but through a small scope using a medium or higher power, it's evident that this is not a star.

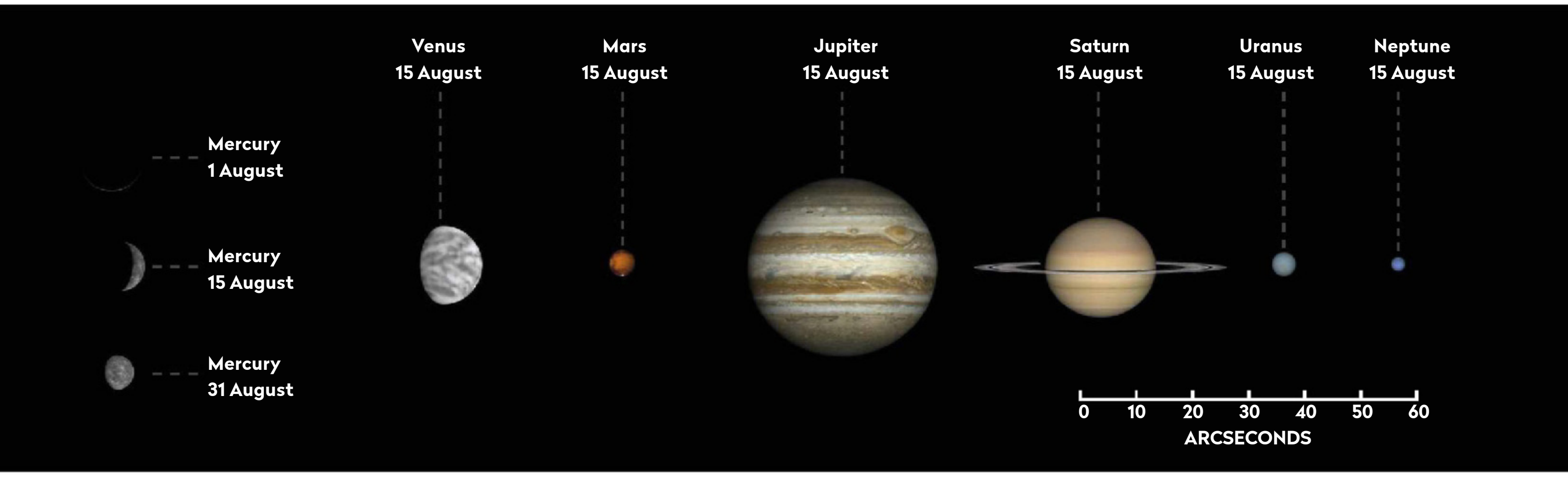
Larger instruments may show subtle banding on the planet's globe, but this can be very difficult to pick out even when using planetary imaging setups. Using an imaging arrangement with a high image scale, an extended exposure can be used to reveal the planet's five brightest moons.


▲ A Seestar shot showing a smattering of moons and Uranus's tell-tale green hue

PETE LAWRENCE X 2

The planets in August

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope


Venus
15 August
Mars
15 August
Jupiter
15 August
Saturn
15 August
Uranus
15 August
Neptune
15 August
Mercury
1 August
Mercury
15 August
Mercury
31 August
0
10
20
30
40
50
60
ARCSECONDS

Mercury

Best time to see: 19 August, 40 minutes before sunrise
Altitude: 8° (low)
Location: Cancer
Direction: East-northeast

Mercury reaches inferior conjunction on 1 August and so will be difficult to see until around 19 August, when it emerges from the Sun's glare into the morning sky. On the 19th, it rises a little under 2 hours before the Sun. On this date, it shines at mag. +0.1 and is 2.5° south of the Beehive Cluster, M44, but the morning twilight will mask the cluster stars. A slender 4%-lit waning crescent Moon joins the scene on 21 August, 7.6° northwest of mag. –0.2 Mercury. On 31 August, Mercury rises 1 hour 15 minutes before the Sun and shines at mag. –1.1.

Venus

Best time to see: 12 August, 90 minutes before sunrise
Altitude: 13°
Location: Gemini
Direction: East-northeast

Venus is also in the morning sky and has a very close encounter with mag. –1.8 Jupiter on 12 August, the pair appearing just 52 arcminutes apart (see page 46). On 31 August, mag. –3.8 Venus will be just south of the Beehive Cluster, an encounter just visible in deep twilight from around 04:15 BST (03:15 UT).

Mars

Above the western horizon, Mars is compromised by bright evening twilight after sunset.

Jupiter

Best time to see: 31 August, 04:30 BST (03:30 UT)
Altitude: 23°
Location: Gemini
Direction: East

Jupiter is yet another morning planet. Although it doesn't quite manage to reach an optimal position before sunrise, it's improving rapidly. Shining at mag. –1.8, Jupiter has a close encounter with brilliant Venus on 12 August (see page 46). On 20 August, Jupiter and Venus will be joined by a 10%-lit waning crescent Moon to form a distinctive morning triangle. By the end of the month, Jupiter manages to appear 23° above the eastern horizon before the onset of dawn.

Saturn

Best time to see: 31 August, 02:40 BST (01:40 UT)
Altitude: 35°
Location: Pisces
Direction: South

You won't see much of the wonderful rings around Saturn's globe this month, as they are still tilted edge-on to Earth, but on the plus side, Saturn is able to reach peak altitude under dark-sky conditions from the middle of the month onwards. Shining at mag. +0.5 near the Circlet asterism in Pisces, Saturn is also close to Neptune. By the end of the month, the planet's brightness will have increased slightly to mag. +0.3.

Neptune

Best time to see: 31 August, 02:40 BST (01:40 UT)
Altitude: 36°
Location: Pisces
Direction: South

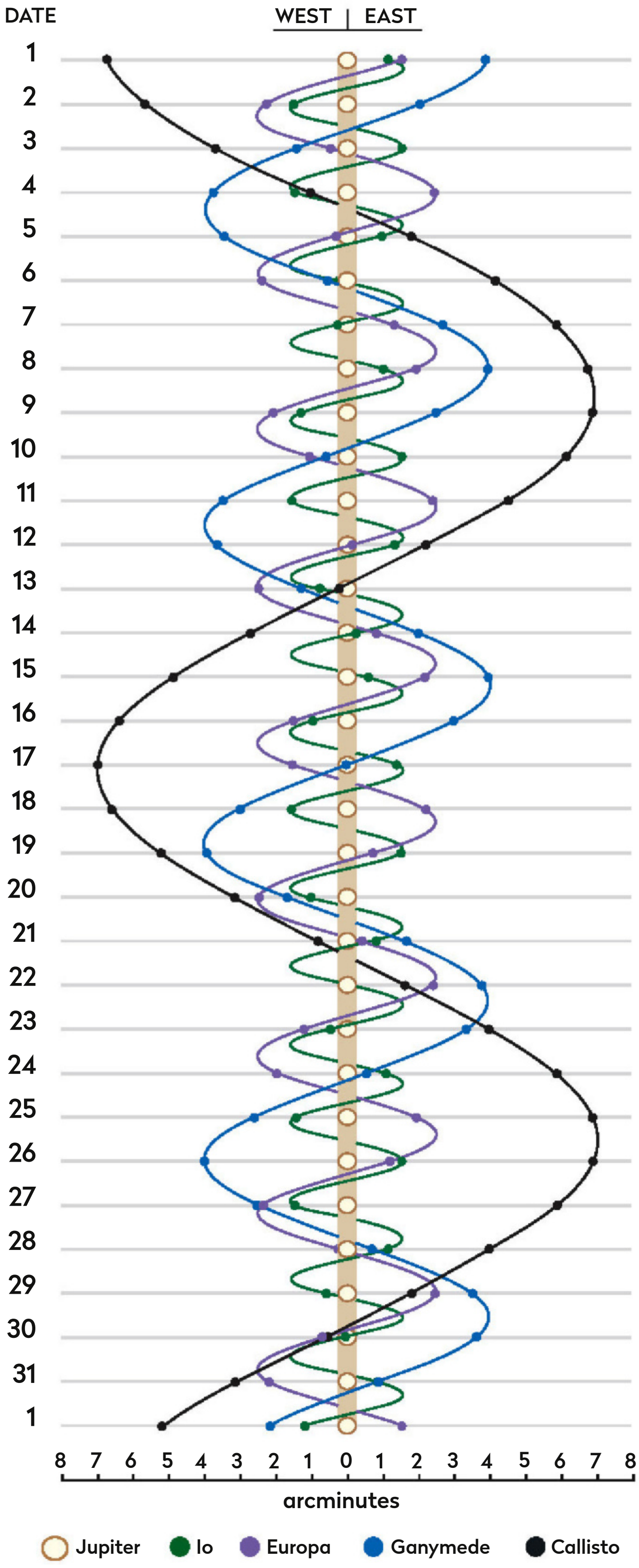
Neptune is just over a degree from Saturn currently and, like the ringed planet, is able to reach maximum altitude under true darkness from the middle of the month onwards.

FREE BONUS CONTENT

Print planet observing forms
www.skyatnightmagazine .com/bonus-content

JUPITER'S MOONS: AUGUST

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



THE NIGHT SKY – AUGUST

Explore the celestial sphere with our Northern Hemisphere all-sky chart

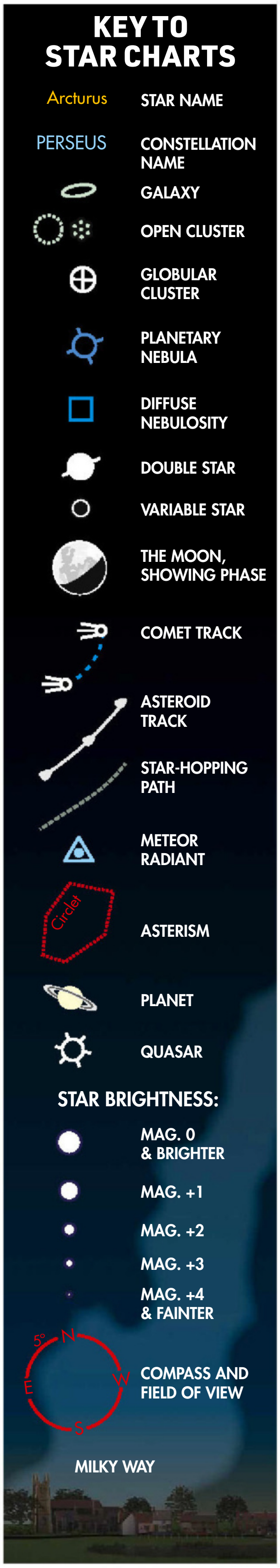

KEY TO STAR CHARTS
Arcturus
STAR NAME
PERSEUS
CONSTELLATION NAME
GALAXY
OPEN CLUSTER
GLOBULAR CLUSTER
PLANETARY NEBULA
DIFFUSE NEBULOSITY
DOUBLE STAR
VARIABLE STAR
THE MOON, SHOWING PHASE
COMET TRACK
ASTEROID TRACK
STAR-HOPPING PATH
METEOR RADIANT
Circlet
ASTERISM
PLANET
QUASAR
STAR BRIGHTNESS:
MAG. 0 & BRIGHTER
MAG. +1
MAG. +2
MAG. +3
MAG. +4 & FAINTER
5°
N
E
W
S
COMPASS AND FIELD OF VIEW
MILKY WAY

CHART: PETE LAWRENCE

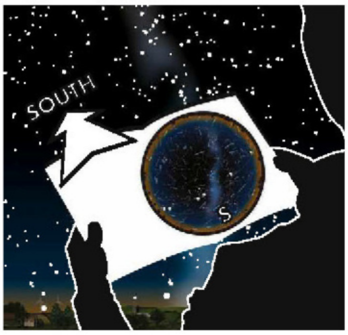
When to use this chart

1 August at 01:00 BST
15 August at 00:00 BST
31 August at 23:00 BST

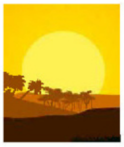
On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.



Sunrise/sunset in August*



Date	Sunrise	Sunset
1 Aug 2025	05:26 BST	21:05 BST
11 Aug 2025	05:43 BST	20:46 BST
21 Aug 2025	06:00 BST	20:24 BST
31 Aug 2025	06:17 BST	20:01 BST

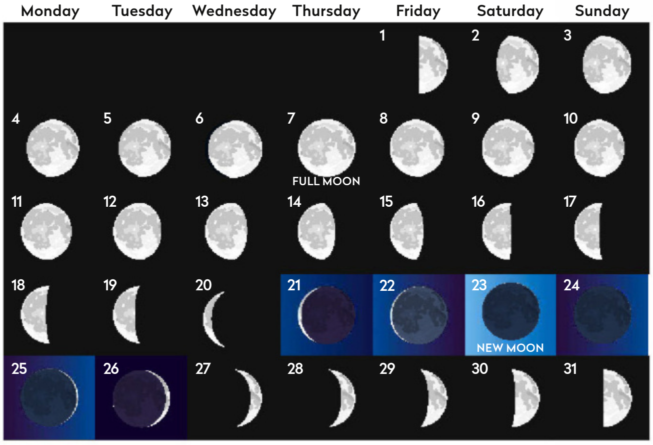
Moonrise in August*

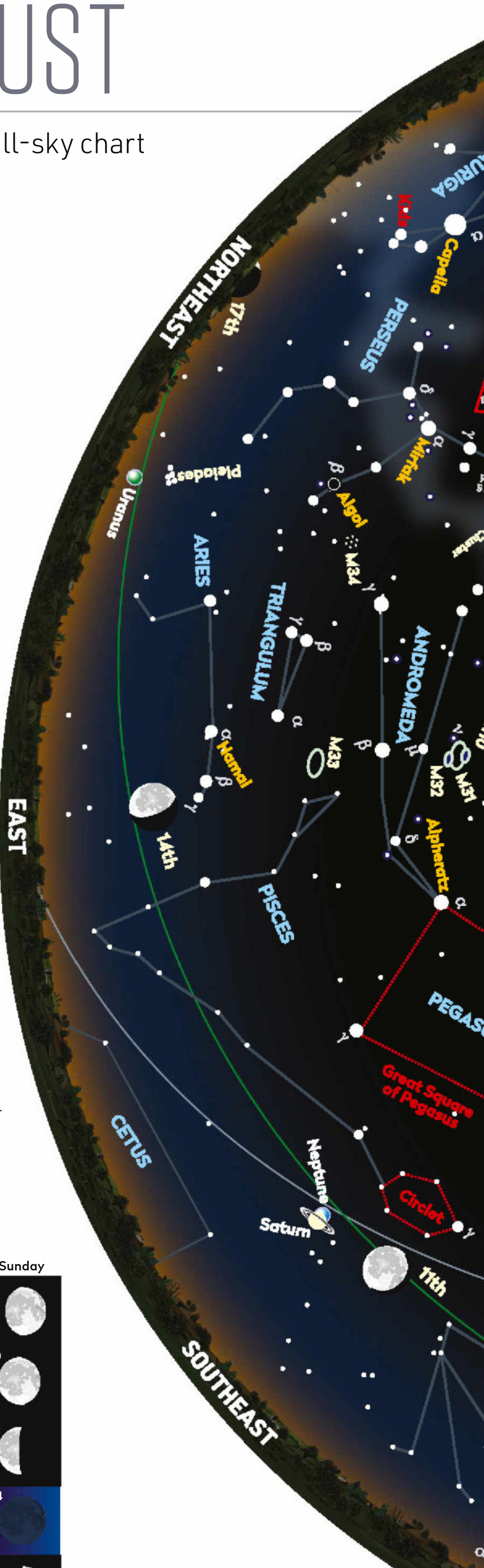
Moonrise times

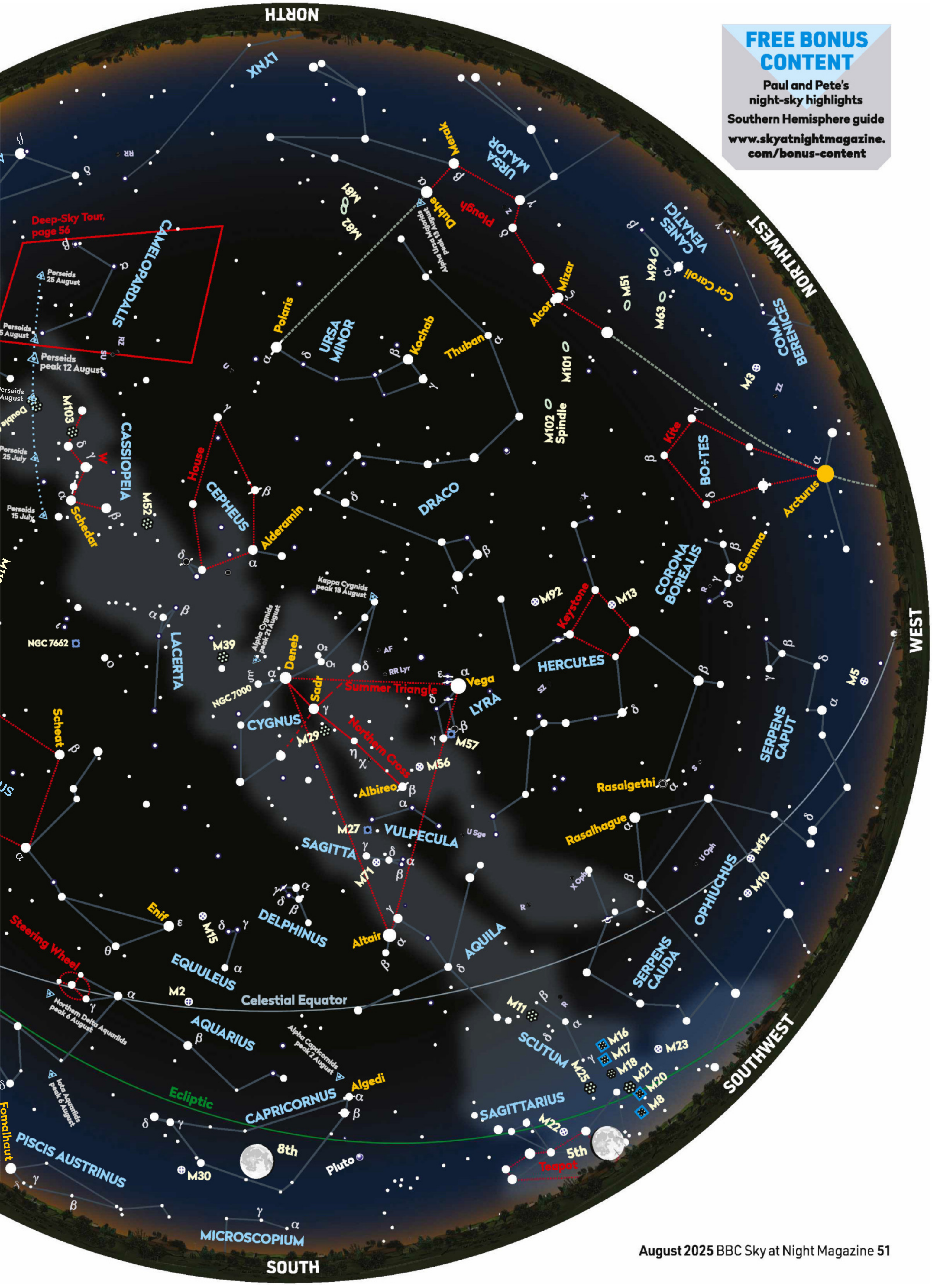
1 Aug 2025, 14:42 BST	17 Aug 2025, 23:26 BST
5 Aug 2025, 19:24 BST	21 Aug 2025, 03:07 BST
9 Aug 2025, 21:13 BST	25 Aug 2025, 08:38 BST
13 Aug 2025, 21:53 BST	29 Aug 2025, 13:40 BST

*Times correct for the centre of the UK

Lunar phases in August


Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday
1
2
3
4
5
6
7
FULL MOON
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
NEW MOON
24
25
26
27
28
29
30
31


URIGA
Kids
Capella
NORTHEAST
17th
PERSEUS
Pleiades
Uranus
Mirfak
Algol
M34
Cluster
ARIES
TRIANGULUM
ANDROMEDA
Hamal
M33
M32
M31
Alpheratz
EAST
14th
PISCES
PEGASUS
Great Square of Pegasus
CETUS
Neptune
Saturn
Circlet
11th
SOUTHEAST


NORTH
LYNX
URSA MAJOR
Merak
Dubhe
Plough
M81
M82
Alpha Ursa Majorids peak 13 August
Deep-Sky Tour, page 56
CAMELOPARDALIS
Perseids 25 August
Perseids 5 August
Perseids peak 12 August
Perseids 5 August
Perseids 25 July
Perseids 15 July
Double Cluster
Polaris
URSA MINOR
Kochab
Thuban
Mizar
Alcor
M51
M94
Cor Caroli
CANES VENATICI
M63
COMA BERENICES
M101
M102 Spindle
M3
NORTHWEST
M103
CASSIOPEIA
W
Schedar
M52
House
CEPHEUS
Alderamin
DRACO
Kite
BOÖTES
Arcturus
CORONA BOREALIS
Gemma
Keystone
M92
M13
HERCULES
Kappa Cygnids peak 18 August
NGC 7662
LACERTA
M39
Alpha Cygnids peak 21 August
Deneb
Sadr
Summer Triangle
Vega
LYRA
NGC 7000
CYGNUS
M29
Northern Cross
M57
M56
Albireo
Scheat
WEST
M5
SERPENS CAPUT
Rasalgethi
Rasalhague
M27
VULPECULA
U Sge
SAGITTA
M71
U Oph
X Oph
OPHIUCHUS
M12
M10
Enif
M15
DELPHINUS
Altair
AQUILA
Steering Wheel
EQUULEUS
M2
Celestial Equator
SERPENS CAUDA
M11
Northern Delta Aquariids peak 6 August
AQUARIUS
Alpha Capricornids peak 2 August
SCUTUM
M16
M17
M18
M23
M25
M21
M20
M8
Ecliptic
CAPRICORNUS
Algedi
SAGITTARIUS
M22
SOUTHWEST
Iota Aquariids peak 6 August
Fomalhaut
PISCIS AUSTRINUS
M30
8th
Pluto
5th
Teapot
MICROSCOPIUM
SOUTH

FREE BONUS CONTENT

Paul and Pete's night-sky highlights

Southern Hemisphere guide

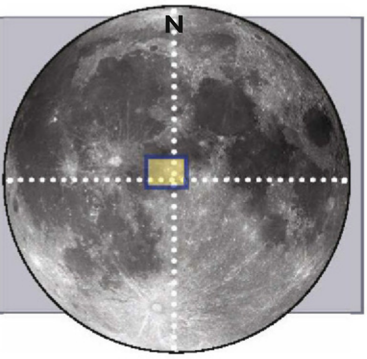
www.skyatnightmagazine.com/bonus-content

MOONWATCH

August's top lunar feature to observe

Flammarion

Type: Walled plain
Size: 75km
Longitude/latitude: 3.7° W, 3.3° S
Age: Older than 3.9 billion years
Best time to see: First quarter (1–2, 31 August); six days after full Moon (16 August)
Minimum equipment: 50mm telescope



Flammarion is an inconspicuous walled plain near the centre of the Moon's disc. On the Earth-facing side of the lunar surface, there are two great crater 'chains' containing three large craters. On the western side of 350km **Mare Nectaris** is the roughly north–south chain formed by 101km **Theophilus**, 98km **Cyrillus** and 100km **Catharina**. Further west, lying roughly on the Moon's central meridian at the same general latitude as the Theophilus chain, and running from south to north, are 98km **Arzachel**, 118km **Alphonsus** and 154km **Ptolemaeus**. Immediately north of Ptolemaeus is 41km **Herschel**. To the north and slightly west of Herschel, lies 75km-diameter Flammarion, appearing like a mini Ptolemaeus.

> **Flammarion appears like a mini Ptolemaeus, its floor lava-covered and remarkably flat**

Its floor is lava-covered and, like Ptolemaeus, remarkably flat, with little evidence of any features visible through smaller amateur telescopes. Larger kit may show some of the 1.5–2km craterlets on the eastern part of the floor, especially the trio of small co-joined craterlets towards the north which, combined, should be a little easier to see, especially under oblique lighting.

Flammarion's rim is very old and quite battered. The southern section appears to be formed from several massifs which are separated at floor level by small gaps. To the southeast is a larger ridge that rises to around 1,600 metres. To the north, the rim is open, co-joining Flammarion to 31km **Mösting M**, a severely battered feature hardly recognisable as a crater. About half of Mösting M's rim is missing and the crater's floor is flat with a rough texture.

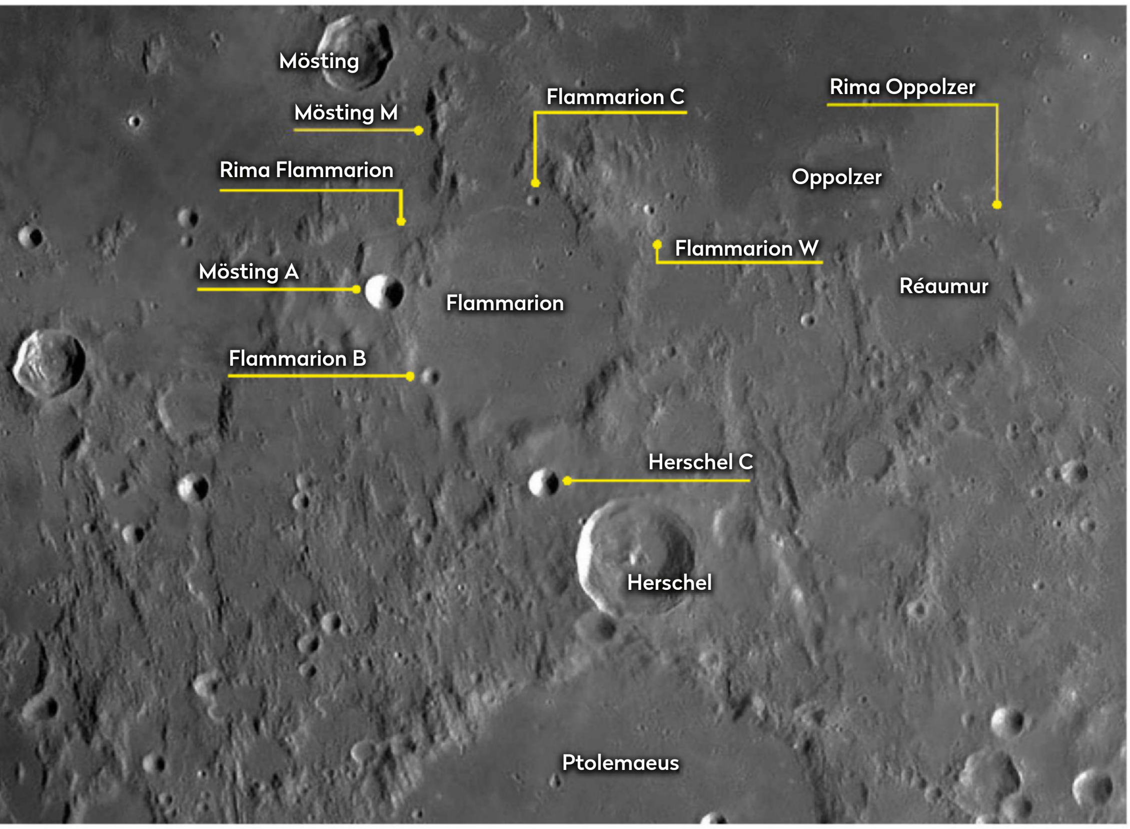
The northern part of Flammarion's floor contains 4.3km **Flammarion C**, nestled within a small northern extension to the main crater rim. Running east–west across Flammarion's floor immediately south of Flammarion C is **Rima Flammarion**, a trench 70km or so long and 2km across at its widest section to the west, narrowing to 1.2km south of Flammarion C. Outside of Flammarion's northeast rim, the rille appears to continue east, becoming a feature known as **Rima Oppolzer**. This runs east from 6km **Flammarion W** for around 170km.

Returning to Flammarion, the distinctive 12km crater embedded in its western rim is 12km **Mösting A**, Mösting being the youthful, sharp 27km crater further to the north. Similarly, the 10km crater immediately south of Flammarion is a satellite of Herschel, known as **Herschel C**. The smaller 6km craterlet that sits between them, roughly two-thirds of the way from Herschel C towards Mösting A, is **Flammarion B**.

It's interesting to contemplate what the Moon's surface would look like from inside a walled plain such as Flammarion. Standing at its centre, your horizon would appear flat, with only the edge of the floor visible as your horizon – apart from to the southeast, where you'd see the rounded peaks of the highest section of Flammarion's western rim poking up.

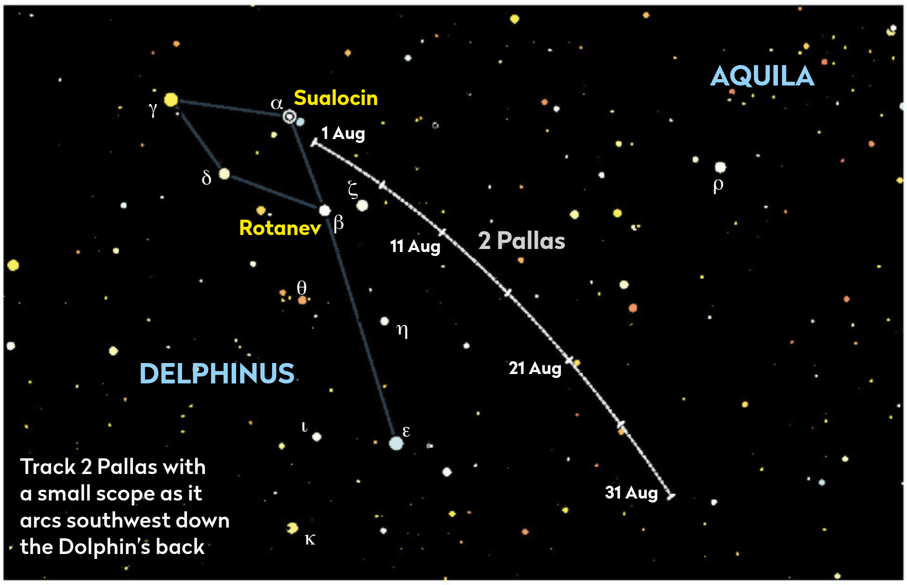
PETE LAWRENCE X 3

▼ Flammarion crater is named after the French astronomer and sci-fi author Camille Flammarion



COMETS AND ASTEROIDS

Large minor planet Pallas is on view all month



Track 2 Pallas with a small scope as it arcs southwest down the Dolphin's back

Minor planet 2 Pallas reaches opposition on 10 August, when it can be found among the stars of Delphinus, the Dolphin. The pattern of stars that forms Delphinus is distinctive, resembling a small diamond with a tail (the diamond is the dolphin's nose, the tail the start of its neck). A familiar highlight of summer skies, it acts as an excellent guide for locating Pallas at the start of the month.

Pallas arcs from a position near Sualocin (Alpha (α) Delphini) on 1 August, away to the southwest over the course of August to end up near the Delphinus–Aquila border. Conveniently, Pallas remains within the confines of Delphinus all month and maintains a constant mag. +9.4. Although too faint for average binoculars, a small telescope will pick it out easily.

Pallas is a large minor planet, second only in size to 4 Vesta. It has a mean diameter of around 513km. It can reach mag. +8.0 under favourable oppositions. At its dimmest, it fades to mag. +10.6, so it's not particularly optimal in 2025.

Pallas was discovered by Heinrich Olbers on 28 March 1802, but this was something of a close call. The French comet-hunter Charles Messier recorded it 23 years before Olbers, but failed to recognise Pallas as a Solar System body, noting it down as a star. In 1801, Giuseppe Piazzi made his famous discovery of 1 Ceres, initially believing it to be a comet. It was while attempting to relocate Ceres after it was lost from view that Olbers inadvertently discovered Pallas.

STAR OF THE MONTH

SS Cygni, a star that's timed to shine

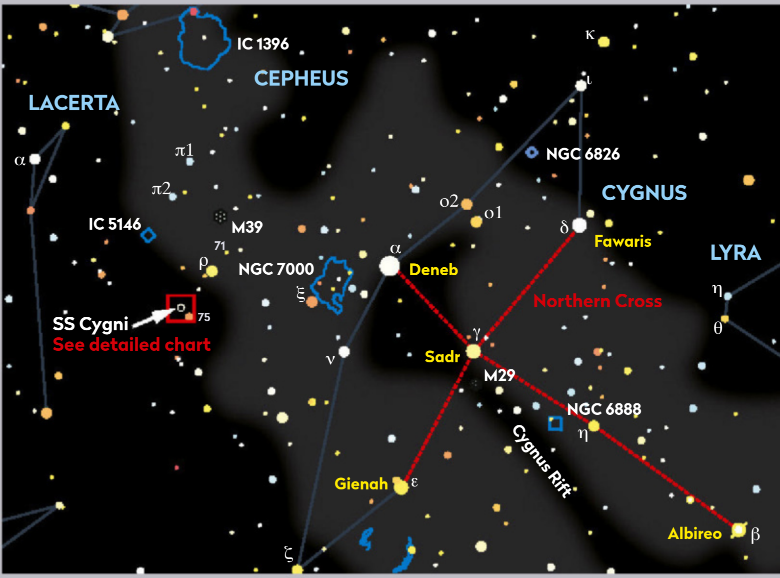
SS Cygni is a variable star in the northeast corner of Cygnus, the Swan. This is a cataclysmic variable consisting of two stars in close orbit around one another. One is a red dwarf, the other a white dwarf. When we say close, this isn't an exaggeration: they're just 160,000km or less apart.

Being this close, the massively dense white dwarf pulls material from the red dwarf, forming an accretion disc around the white dwarf, with matter spiralling inwards. Some of this hydrogen-rich material undergoes a runaway fusion reaction that raises the brightness of the system.

From Earth, SS Cygni typically presents itself as a 12th-magnitude star, but every 7–8 weeks it undergoes an outburst due to the fusion process, rising to eighth magnitude for 1–2 days. This makes SS Cygni a perfect target for small telescopes and, thanks to the backdrop of Milky Way star fields, there are plenty of comparison stars to use to make a magnitude estimate. Use the chart to locate SS Cygni, then see the detailed chart on page 55, where we walk through how to plot a light curve for the star.

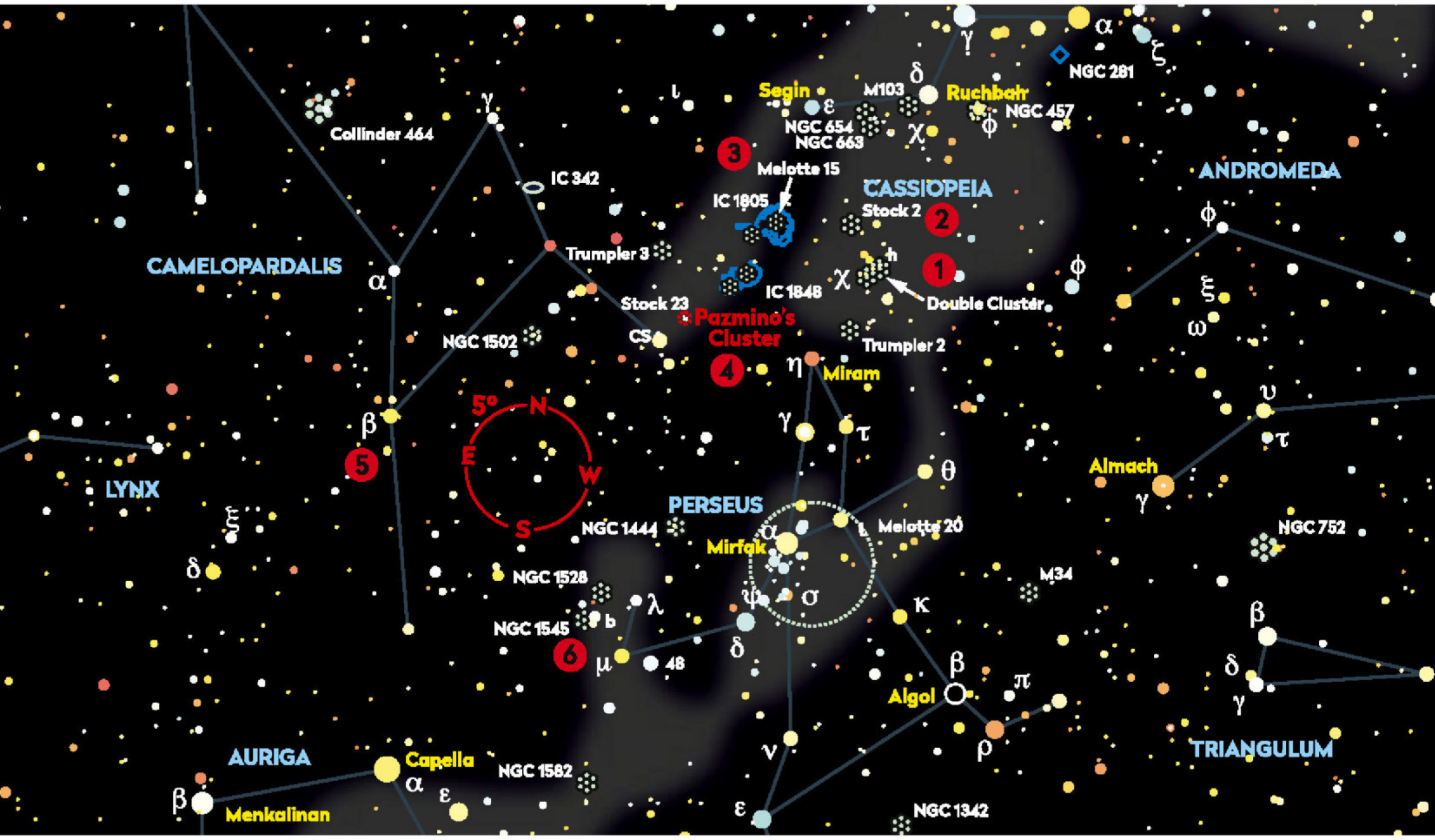
SS Cygni is a relatively nearby dwarf nova cataclysmic variable, located 372 lightyears from the Sun. The binary orbit is very short at just 6.5 hours, the orbital inclination of the system being around 50°. The red dwarf is 55 per cent as massive as our Sun, while the matter-gobbling white dwarf is 81 per cent.

▼ To locate the SS Cygni field, star-hop from Deneb (Alpha (α) Cygni) to Rho (ρ) Cygni. From there, find mag. +5.1 75 Cygni



BINOCULAR TOUR With Steve Tonkin

Discover a stick man flexing his biceps, a golden giant and the sublime Double Cluster


Collinder 464
IC 342
Segin
M103
Ruchbah
NGC 457
NGC 281
NGC 654
NGC 663
3
Melotte 15
IC 1805
CASSIOPEIA
Stock 2
2
ANDROMEDA
CAMELOPARDALIS
Trumpler 3
IC 1848
1
Double Cluster
Stock 23
Pazmino's Cluster
NGC 1502
CS
Trumpler 2
4
Miram
5°
N
E
W
S
5
LYNX
PERSEUS
NGC 1444
Mirfak
Melotte 20
Almach
NGC 752
NGC 1528
M34
NGC 1545
6
48
Algol
AURIGA
Capella
NGC 1582
Menkalinan
TRIANGULUM
NGC 1342

1. The Perseus Double Cluster

15x70 A third of the way from mag. +3.8 Miram (Eta (η) Persei) to mag. +2.6 Ruchbah (Delta (δ) Cassiopeiae), you will find a close pair of open clusters. The pair may be visible to your naked eye, but large binoculars will help you to experience the 3D illusion that makes it so attractive. Those stars are intrinsically far brighter than our Sun, which, if it were at that distance, with these binoculars would be too faint to be seen! ☐ **SEEN IT**

2. The Muscleman Cluster

10x50 From the part of the Double Cluster that is nearest Cassiopeia, there is a 2° curved chain of eighth-magnitude stars leading to the north. They guide you to Stock 2, the Muscleman Cluster. You will recognise it from the sparse X-shaped pattern of brighter stars which, on closer observation, have the form of a stick man who is flexing his biceps and apparently keeping the Double Cluster on a leash. ☐ **SEEN IT**

3. Melotte 15

10x50 Melotte 15 marks the southeastern apex of an equilateral triangle with mag. +3.3 Segin (Epsilon (ε) Cassiopeiae) and mag. +4.6 Iota (ι) Cassiopeiae. You should be able to resolve at least half a dozen stars in a narrow 'V' shape from this bright, large glow. Unless you have exceptional skies, you are unlikely to be able to detect the surrounding nebulosity (IC 1805, the Heart Nebula) that gave birth to the cluster. ☐ **SEEN IT**

4. Pazmino's Cluster

10x50 Navigate 1.5° due west from mag. +4.2 CS Camelopardalis to find a little trapezium of seventh- and eighth-magnitude stars. This is Stock 23, also known as Pazmino's Cluster, named for John Pazmino who popularised it in the 1970s. In 50mm binoculars, it's much more than a trapezium; depending on your sky conditions, you may be able to resolve half a dozen stars against a 10-arcminute-diameter glow. ☐ **SEEN IT**

5. Beta Camelopardalis

10x50 Beta (β) Camelopardalis is easily visible to your naked eye at mag. +4.0. It has a mag. +7.4 companion 84 arcseconds to the southwest. Beta Cam is classified as a yellow supergiant and is a relative youngster at a mere 40 million years old. Keep an eye on it – you may see it brighten by a whole magnitude in a 0.25-second flash, possibly its equivalent of a huge solar flare. ☐ **SEEN IT**

6. The 'Other Double Cluster'

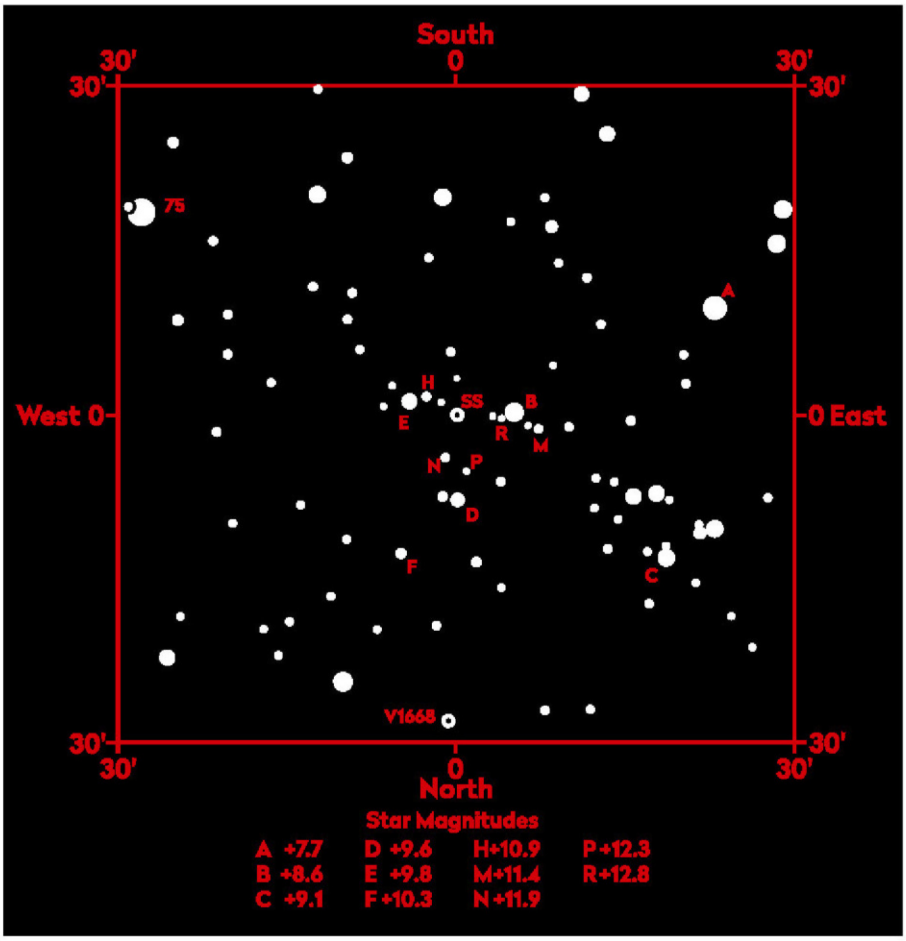
15x70 A couple of 15x70 fields of view (8°) east of mag. +1.8 Mirphak (Alpha (α) Perseii), you'll see the obvious cluster NGC 1528, which is rich and compressed. Its companion, NGC 1545, which lies slightly more than a degree southeast, is smaller, sparser and marginally brighter. They are both about 2,500 lightyears away and so offer a good example of the variety that exists in open clusters. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

THE SKY GUIDE CHALLENGE

Star SS Cygni lights up on schedule. Can you track the changes in its brightness?



▲ A closer look at the star field surrounding SS Cygni (see page 53 for the general location)

SS Cygni is an amazing variable star in the constellation of Cygnus, the Swan. You can read more about how the star behaves on page 53. For this month's challenge, we're going to look at how to observe, record and plot its light curve. The techniques can be applied to any variable star.

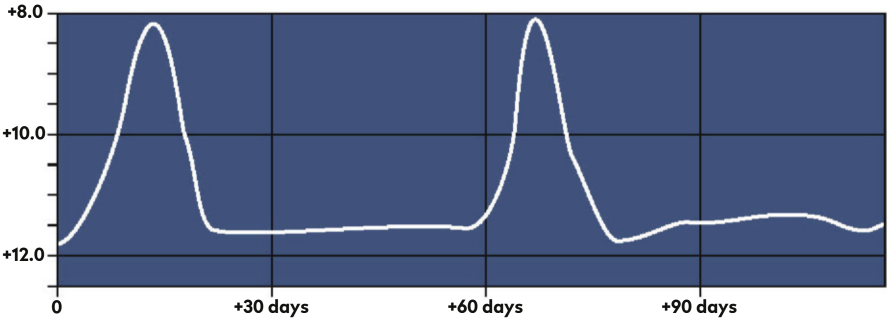
The first task is to locate SS Cygni. You can use the general location chart on page 53, together with the comparison chart here to identify the field of view. Once you've located the correct field, take your time and get acquainted with the comparison stars shown. There are various ways these stars can be used to record the brightness of a variable like SS Cygni. One is to pick two comparison stars, one brighter than SS Cygni and one dimmer. Once you have done this, make an estimate as to where SS would fit along a brightness scale between the two. For more information about how to observe variable stars, take a look at our article at **www.skyatnightmagazine.com/advice/observe-variable-stars**.

Ideally, for the best accuracy, choose comparison stars that are within 0.5 magnitudes of one another. Subdivide the scale between the two comparison stars into three. Using our chart, you might estimate that SS Cygni is dimmer than C but brighter than D. Here you need to estimate where SS Cygni would sit along the brightness line between both comparisons. Say you estimated it to be one third along the line from D, and two thirds from C, you would write C(2)v(1)D. Using this notation, 'v' represents the variable star, in this case SS Cygni.

> ***"Pick two comparison stars, one brighter than SS Cygni and one dimmer"***

Once you've made the observation, you can calculate the magnitude of SS Cygni by dividing the difference between the two comparison stars, in this case 9.6–9.1 = 0.5, by the division scale, which is three. Each division represents 0.5/3 = 0.17 magnitudes. Using our example observation – (C(2)v(1)D) – the magnitude of SS Cygni is 0.34 dimmer than C and 0.17 brighter than D. This gives 9.1+0.34 = +9.44 and 9.6–0.17 = +9.43. Accuracy to one decimal place gives SS Cygni's magnitude as +9.4.

Now you have a magnitude, you're ready to plot this point on a light curve. This is the easy part: just create a graph with Date along the bottom and Magnitude up the side. Make as many observations as you can, and over time you'll see the star's light curve being formed, and hopefully you'll catch an outburst. If you get a taste for this, there are many exciting variable stars out there to observe. You'll need comparison charts for each one – these can be readily obtained from organisations such as the BAA, SPA and AAVSO.



▲ SS Cygni's light curve typically shows short-lived outbursts occurring every 7–8 weeks

DEEP-SKY TOUR

Faint Camelopardalis is hiding some tricky-to-spot deep-sky gems. Can you find all six?

1 Collinder 464

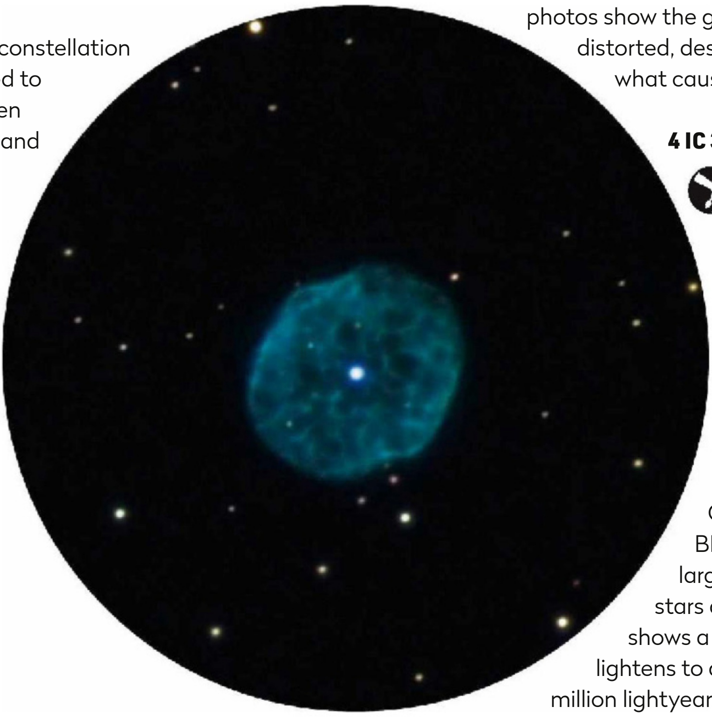
The faint, rather indistinct constellation Camelopardalis is supposed to represent a giraffe. It sits between Polaris (Alpha (α) Ursae Minoris) and Capella (Alpha (α) Aurigae). Our first target is located one third of the way along the line from Polaris to Capella and fittingly is rather indistinct too. Collinder 464 is an open cluster that appears as a sparse collection of sixth- and seventh-magnitude stars centred around the fifth-magnitude variable BN Camelopardalis. Using a low power, it's just about possible to visualise this grouping of blue, white and orange stars strewn over a 2° area. ☐ **SEEN IT**

2 NGC 1560

This is a mag. +11.5 galaxy 3.6° southwest of BN Camelopardalis. Navigating this area is challenging, not only because of the faintness of Camelopardalis – its brightest star is mag. +4.0 Beta (β) Camelopardalis – but also its proximity to the North Celestial Pole. For equatorially mounted scopes, this can be too tricky to navigate manually. Through the eyepiece of a 250mm instrument, this low-surface-brightness galaxy appears as a faint elongated smudge 4 x 1 arcminutes in size, with no distinct brightening of the core. A 300mm scope hints at extensions to this sideways-on spiral's length, but reveals little in the way of structure. ☐ **SEEN IT**

3 NGC 1961

To locate the intermediate spiral galaxy NGC 1961 (Arp 184), we recommend finding mag. +4.3 Alpha (α) Camelopardalis 5.8° south-southeast of NGC 1560. If you didn't find our second target, Alpha is the brightest star near the mid-point of the line between Polaris and Capella. NGC 1961 is 5.5° northeast of Alpha. This is tough through a 150mm scope, but a 250mm scope reveals it as a distinct 2 x 1-arcminute ellipse, with little apparent texture. A 300mm scope shows an object roughly twice as large with a hint of mottling over the core. Located 200 million lightyears away, long-exposure photos show the galaxy to be significantly distorted, despite there being no evidence of what caused the distortions. ☐ **SEEN IT**



▲ **Our final stop is the planetary nebula NGC 1501. You'll need hefty aperture to see its central star**

MICHAEL BREITE/STEFAN HEUTZ/WOLFGANG RIES/CCDGUIDE.COM, CHART BY PETE LAWRENCE

4 IC 342

IC 342, another intermediate spiral galaxy, appears face-on to us. Known as the Hidden Galaxy, it's quite large at 18 x 17 arcminutes and, on paper, is bright at mag. +9.1. It's relatively easy to see as a large, faint patch through smaller scopes, midway between mag. +4.6 Gamma (γ) Camelopardalis and mag. +4.4 BE Camelopardalis. Through larger scopes, several foreground stars are evident. A 300mm scope shows a fairly bright centre that lightens to a star-like core. Lying 10.7 million lightyears away, IC 342's nickname comes from its brightness being dimmed by dusty regions in our own Galaxy. If these weren't present, you'd be able to see it with the naked eye! ☐ **SEEN IT**

5 NGC 1502

Open cluster NGC 1502 lies 3.7° southeast of HIP 17884, but it's easier to find by starting at the binocular asterism Kemble's Cascade. This is a linear string of stars almost 2.5° in length, easily located by extending the line from Caph (Beta (β) Cassiopeiae) through Segin (Epsilon (ε) Cassiopeiae) (not shown on chart) for the same distance again. The cascade is sometimes described as resembling a waterfall of stars; the open cluster NGC 1502 is the 'splash pool' at the southeastern end. The 8-arcminute cluster has an integrated magnitude of +5.7 and contains around 60 stars. A 250mm scope reveals about a quarter of this number, 300mm increasing the count to nearly 40. ☐ **SEEN IT**

6 NGC 1501

For our final target, simply head 1.4° south from NGC 1502. Planetary nebula NGC 1501 is a mag. +11.5 object that's 1 arcminute or so in diameter. A larger instrument is recommended here, using a medium to high power. A 250mm scope reveals it as a bright, round object, but its central star may elude you. A 300mm *will* show the mag. +14.5 central star, as well as revealing the nebula to have an annular appearance with a gently shaded central 'hole'. NGC 1501 is also known as the Oyster or, perhaps more fittingly, the Camel's Eye. It's estimated to be 4,240 lightyears away and physically to be around 1 lightyear in diameter. ☐ **SEEN IT**

This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can take you to this month's targets at the touch of a button. Find the Deep-Sky Tour file in our free Bonus Content online.

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Print this chart and take the Go-To tour
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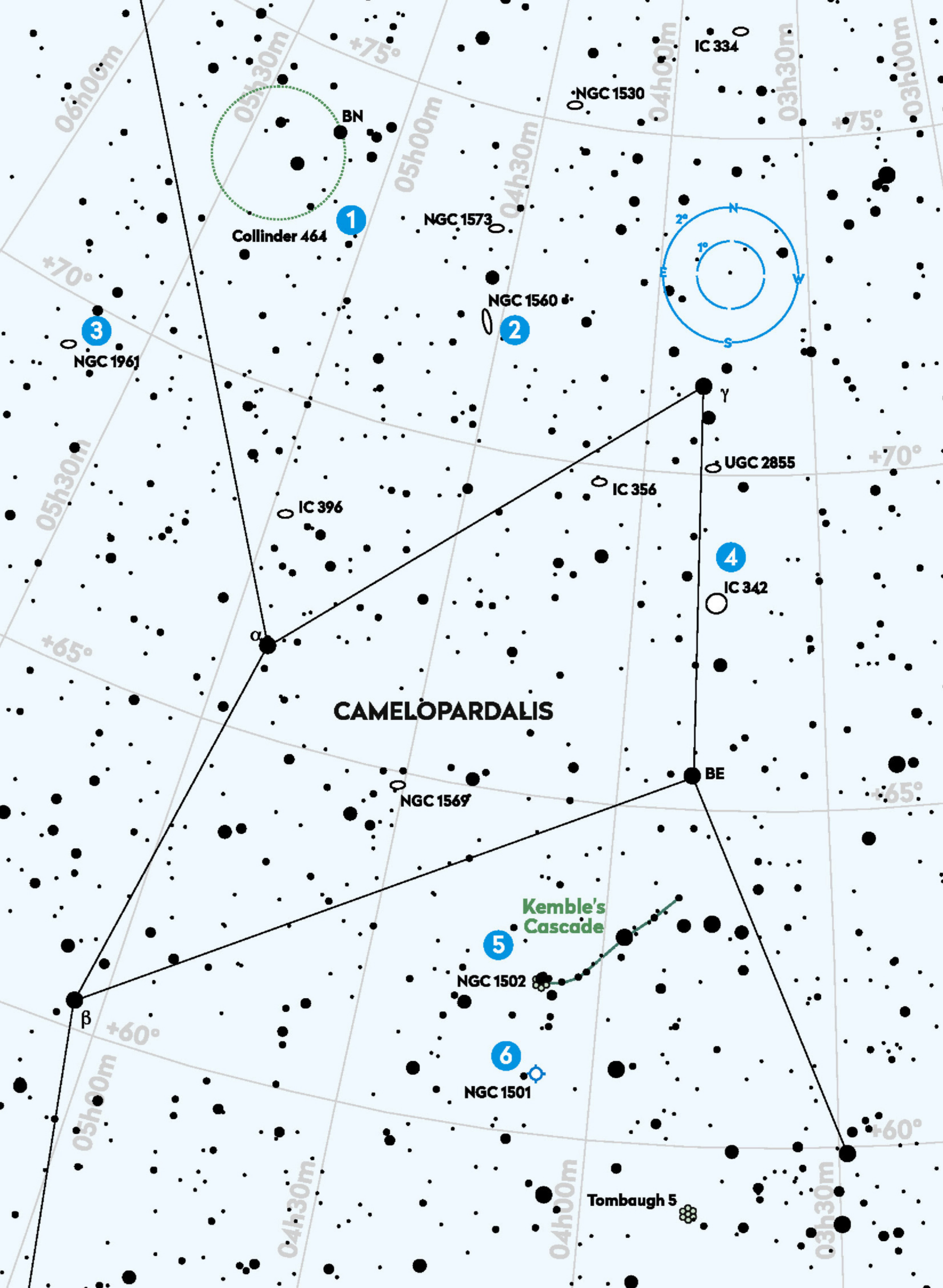
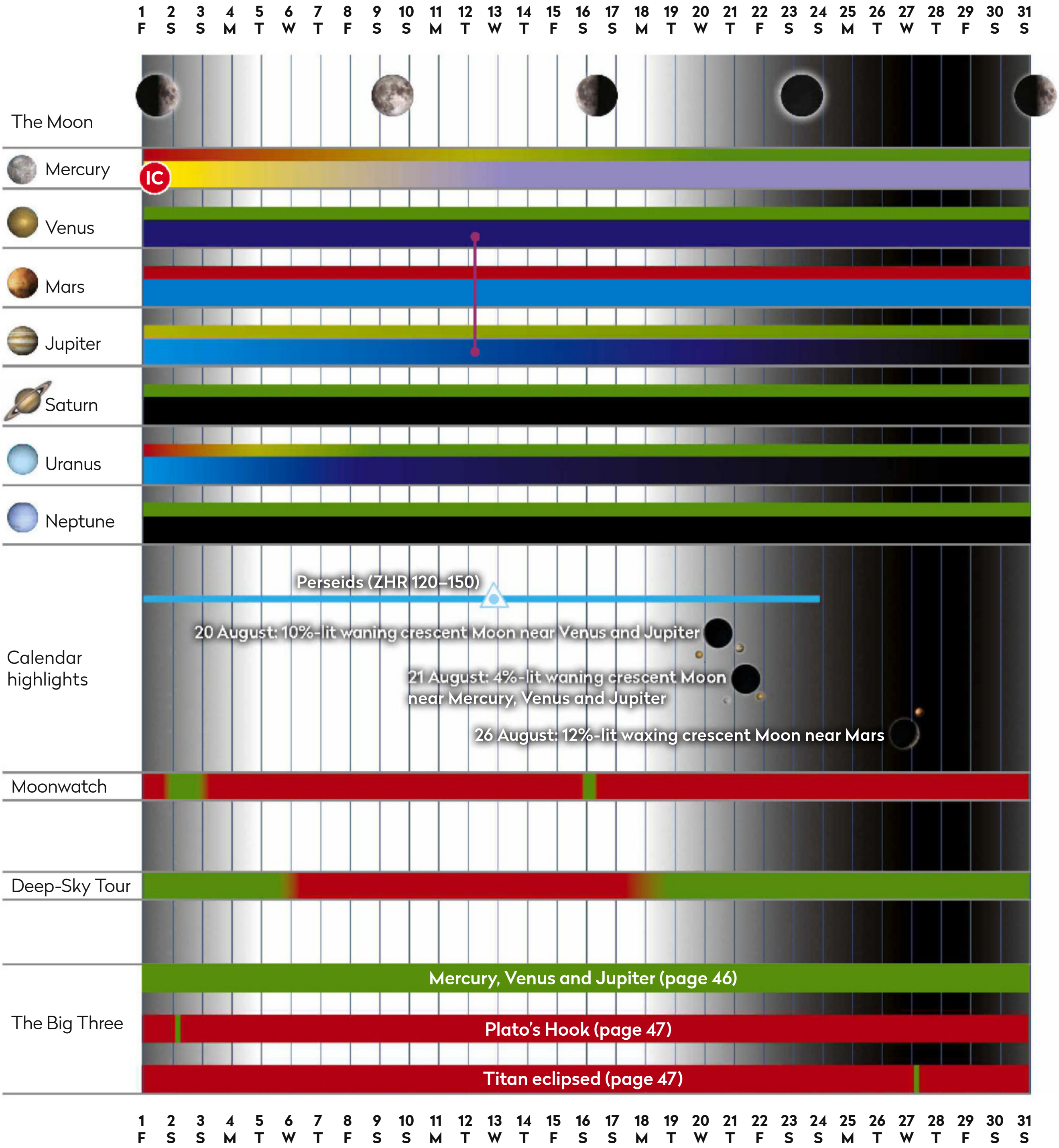

06h00m
05h30m
+75°
05h00m
04h30m
04h00m
IC 334
NGC 1530
03h30m
03h00m
+75°
BN
1
Collinder 464
NGC 1573
N
2°
1°
E
W
S
+70°
NGC 1560
2
3
NGC 1961
γ
05h30m
UGC 2855
+70°
IC 356
IC 396
4
IC 342
+65°
α
CAMELOPARDALIS
BE
NGC 1569
+65°
Kemble's
Cascade
5
NGC 1502
β
+60°
6
NGC 1501
05h00m
+60°
04h30m
04h00m
Tombaugh 5
03h30m

AT A GLANCE

How the Sky Guide events will appear in August



KEY

Observability

🟩 Optimal
🟥 Poor

Best viewed

Morning twilight
Daytime
Evening twilight
Night

Sky brightness during lunar phases

Dark (first quarter)
Light (full Moon)
Dark (last quarter)
Total darkness (new Moon)

IC Inferior conjunction (Mercury & Venus only)
SC Superior conjunction
OP Planet at opposition
△ Meteor radiant peak
Planets in conjunction

Full Moon
First quarter
Last quarter
New Moon

CHART BY PETE LAWRENCE

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Northern Light cruises blend untamed landscapes, Arctic exploration and – by night – the greatest show on Earth: the aurora borealis

HURTIGRUTEN X 2

HURTIGRUTEN
NORDLYS

Jamie took an 11-night cruise along the Norwegian coast from Bergen up to Kirkenes and back

Set sail for the Northern Lights

As interest in the Northern Lights increases, cruise companies are making travelling to the Arctic Circle easier. **Jamie Carter** went aboard to Norway and found out what they're like

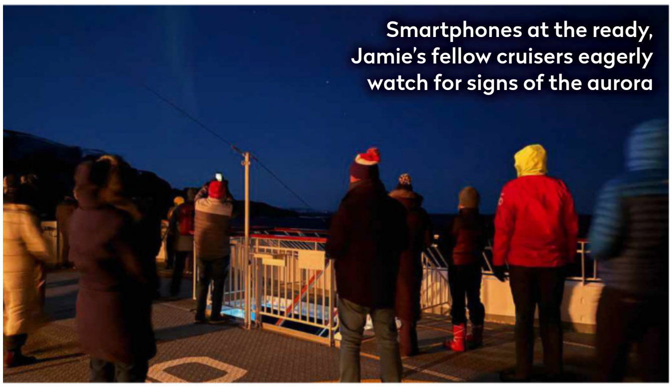
We were at latitude 71° north, in the Barents Sea off Norway, when we got our first "Wow!" moment. No geomagnetic storm had been predicted, but there, around the stars of Cassiopeia, a greenish curtain was weaving across the sky. A sea of smartphones was lifted and seconds later there were beaming smiles all round.

It hadn't begun like this. The Hurtigruten cruise ship MS Nordkapp had travelled under cloudy skies for several days as it plied the Norwegian coast on its regular 11-night route from Bergen to Kirkenes and back. It called in at remote fishing villages, delivering parcels and picking up supplies, and occasionally dropping off passengers to go dog sledding or snowmobiling, or attend a Viking-themed dinner.

Settling into cruise life

The first few days were taken up by astronomy lectures and there was plenty of time to sample locally sourced ingredients from the places we were constantly passing. The entire ship was treated to blue mussels grown off Trondheim, while some sampled bottles of sparkling wine aged for six months in the Norwegian Sea. This being Norway, ▶

A warm bar nearby and a breathtaking spectacle above. What could be better?



Smartphones at the ready, Jamie's fellow cruisers eagerly watch for signs of the aurora

Calm waters as the ship heads into a fjord – but it's a good idea to pack your sea legs, says Jamie

▶ there was always beautifully cooked cod on hand – even some cod-flavoured ice cream for dessert. As aurora hunts go, this was as relaxing as it gets.

The regular nightly excursion, however, was to the seventh deck to check on the status of the aurora, or rather, the weather. "Seeing the aurora from the ground is fantastic, but if you want to be on the move, constantly moving into better skies, and you want to experience polar exploration yourself, then I think being on a ship sailing into the Arctic is a special way to do it," says Tom Kerss, author of the book *Northern Lights: The Definitive Guide to Auroras* and Hurtigruten's Chief Aurora Chaser.

Kerss, who spends each cruise delivering lectures on everything from stargazing in polar regions to aurorae on other planets, is there to help passengers set up their cameras and give advice on how exactly to take images on a moving ship that frequently has to negotiate rough seas.

Ah yes, the waves. One thing you certainly need for a Northern Lights cruise is a pair of sea legs. On a couple of occasions, waves reached as high as 6 metres (20ft), which left passengers scurrying to their cabins to wait it out. However, the beauty of a coastal cruise is that the ship very often travels through narrow fjords and channels where the waters are much calmer. Not only was the majority of the journey smooth, but the weather was ever-changing. Even with a storm system in effect, there were gaps in the weather which belied the regional forecasts. The theory goes that while on its predetermined schedule of stops, the ship will inevitably sail into clear (and dark) skies. This in itself improves the chances of seeing the aurora.

Skywatching in style

Cruise ships aren't usually known for astronomy. Try seeing the night sky from your average cruise voyage around the Mediterranean, for example, and you'll be out of luck – not just because it's farther south, but because the lights on deck never go off. Luckily, our ship had minimal lighting on the main viewing deck. It also had an undercover area with chairs and heat lamps, and the option of going inside to the bar area, just the other side of the doors, to warm up.

During my cruise, there were always one or two passengers on deck with cameras at the ready, even on cloudy nights. But on a few occasions, ship-wide

KAY FOCHTMANN, JAMIE CARTER X 2, TOM KERSS X 2

Photographing the aurora from a ship

Here's how to take steady shots when you're on a moving object

Capturing the aurora has become far simpler, especially with modern smartphone cameras, which are now well-suited for shooting the Northern Lights from a moving ship. These devices can effectively handle short exposures, making them ideal for this scenario, and they can produce impressive videos of the aurora that were once only possible with expensive cameras. They're so good that you can also use them to check that what you're seeing is actually the aurora.

The key to success lies in the smartphone's night mode. Newer smartphones have significantly enhanced low-light capabilities, with night mode on the iPhone allowing for long exposures anywhere from three to 10 seconds. Android users can experiment with Pro mode, which gives manual control over settings like shutter speed and ISO. Increasing the ISO to 6400 or higher can help capture more light, though some graininess may occur. Shooting in raw format captures more data for post-processing, but takes up more storage.

On land, use a tripod or steady the device on a stable surface to reduce blur, but on a ship it's best to stick to a few seconds (though in the calm fjords and channels, longer exposures are definitely possible). If you're using a manual camera, minimise exposure time by shooting at the widest aperture possible (lowest f/ number) and using a high ISO. Software like DXO Pure can help reduce noise in post-processing.

On-board aurora guru Tom Kerss helped passengers successfully snap the show

▲ Auroral displays at northerly latitudes can be spectacularly vivid and colourful

announcements about sightings of aurorae were made through the speakerphones in each cabin. I noticed that it took passengers at least 10 minutes to come outside, which meant some missed out on the fleeting displays. Having clocked that aurorae can come and go quickly, I spent each evening in the bar, yards from the viewing deck, with my coat and camera at the ready. It paid off – I was among the first to see the aurorae each time they appeared.

Kerss wisely began the cruise by managing the expectations of passengers wowed by images they'd seen previously of bright green aurorae. "When we look at the Northern Lights, we're relying on the rod cells [in our eyes] to give us the sensitivity to make them visible, and whatever colour information our cone cells can get, so our brain has very little colour information to work with," he explained. "So our perception of colour [in an aurora display] is very muted, but it is there, and the longer you spend looking, the more of it you will see."

The science behind the lights

It is, of course, a boom time for the aurora. Understanding why – and how it affects any decision to go aurora-hunting – requires a little understanding of the science. The Northern Lights are caused by the way that Earth's atmosphere interacts with the solar wind, which acts like a large electric current running throughout the Solar System. Earth's magnetic field normally protects us from the solar wind, but also allows some of its charged particles to get through into the magnetosphere (the region of space around our planet where its magnetic field is dominant).

Earth and the Sun (and, by extension, the solar wind) can be thought of as magnets with magnetic fields. "As the magnetic field of the solar wind interacts with Earth's magnetic field and the two are inversely orientated, a lot of that solar wind material [charged particles] finds its way into Earth's magnetic environment," says Kerss. "When it gets close enough to the inner part of Earth's magnetic field, it inherits a lot of energy, and it can be injected into the atmosphere above our heads to create aurorae." ▶

▲ **Right place, right time: sailing into the Arctic Circle means passengers get a front-row seat when the sky erupts**

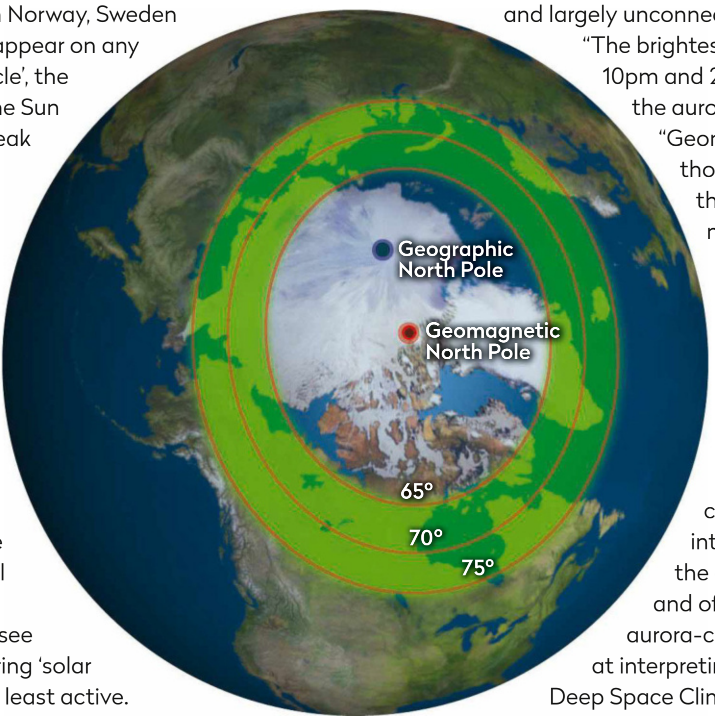
▶ It's when magnetic field lines realign, something called magnetic reconnection, that the aurora is created. The visible light of an aurora display is the result of negatively charged particles – electrons – striking atoms in our atmosphere. These atoms then release the energy as light.

Aurorae are typically seen in polar regions, at latitudes around 66° north and south, which in the Northern Hemisphere includes Alaska, Canada, Iceland, Greenland and northern Norway, Sweden and Finland. Here, displays can appear on any night, regardless of the 'solar cycle', the Sun's 11-year cycle of activity. The Sun is currently at or very near the peak of this cycle, what astronomers call 'solar maximum', which is when magnetic activity is at its greatest.

In the glow zone

At this time, the Sun is more likely to produce coronal mass ejections – great outbursts of charged particles – that can cause geomagnetic storms. None of this, however, significantly affects whether the aurora can be seen in the auroral zone around latitudes 66° north and south: it's easily possible to see the aurora at these latitudes during 'solar minimum', when the Sun is at its least active.

Some will wonder why anyone is travelling to see the aurora when they were visible in the UK in 2024. "During solar minimum, the odds of seeing aurorae in the UK are almost zero, but they increase around and after the solar maximum," says Kerss, noting that the G5 geomagnetic storm in May 2024 was rare and unique. "Ironically, that one was more amazing for the UK than it was for arctic Norway," he says, but he's keen to point out that exceptional views in the UK are just that.



▲ **Aurora displays are an almost nightly event inside the auroral oval**

The key to understanding why you need to head north to see the aurora reliably is the auroral oval, a region around the Arctic Circle where displays of the Northern Lights are a frequent, almost nightly event and largely unconnected to the solar cycle.

"The brightest aurorae are seen between 10pm and 2am, when the viewer is under the auroral oval," Kerss continues. "Geomagnetic storms, especially those as strong as G5, can cause the auroral oval to expand, making aurorae visible at more southerly latitudes."

However, it's not geomagnetic storms that he looks out for as he travels the coast of Norway, but substorms (see right). A substorm is a disturbance in Earth's magnetosphere that causes energy to be released into the ionosphere. It causes the aurora to appear, brighten and often move. In recent years, aurora-chasers have become adept at interpreting the data from NASA's Deep Space Climate Observatory (DSCOVR) and Advanced Composition Explorer (ACE) space weather satellites to predict sudden substorms.

When to go aurora-hunting by ship is no different from land-based chases. Solar maximum means that, in the Arctic regions, there is not only an

TOM KERSS, DAVID CLAPP/GETTY

explosion of interest in aurora-hunting but also a higher likelihood of spectacular all-sky aurora displays during a powerful geomagnetic storm. Solar maximum, predicted to occur in 2025, should mean excellent viewing opportunities in 2025 and 2026. The winter months are best, due to more extended periods of darkness in northern latitudes, though January is often avoided since it's dark all day above the Arctic Circle.

It's also worth avoiding the week before a full Moon. Although moonlight doesn't make aurorae invisible – and does illuminate the landscapes around you (which can be handy for photographers) – it makes fainter displays harder to see.

Another advantage of an aurora cruise is that, if you choose to, you can also experience aurora-chasing on land – another popular excursion. I jumped at the chance, and it was after a busy day spent dog sledding and catching king crab at the remote Snowhotel Kirkenes that the alert went up – an auroral substorm was imminent. A group of us rushed into a minibus with no clear destination, the howls of husky dogs ringing in our ears. Passports were in pockets: Finland was to our right, Russia to our left, the latter out of bounds, but tantalisingly near.

A glorious green grand finale

"The aurora is close – let's see if we can get underneath it!" said our tour leader, Mili. The chase was on. As if tracking a pride of lions from a safari truck, through the minibus windows we followed the dancing polar lights.

By the time we tumbled out onto a remote forest road far from artificial light, a substorm was erupting. Greenish light was being squeezed along Earth's magnetic field lines as if it was coming from a cosmic toothpaste tube.

"Don't spend the whole time looking at your phone," Kerss reminded us. "Stop, look up, remember where you are and how special this is – just watch it!" For 20 minutes, we stood transfixed as the aurora twisted and rippled, waxed and waned until the lights eventually faded into the freezing night. An aurora cruise can give you an experience you'll never forget, but it can also get you to places you would never have otherwise gone.

Jamie Carter is a travel and astronomy writer and author of *A Stargazing Program for Beginners: A Pocket Field Guide*

Aurora cruise lines

See the Northern Lights on the ocean wave

Fancy combining seagoing and skywatching? Here are seven companies that offer just that:

Aurora Expeditions: Northern Lights Explorer
www.aurora-expeditions.com/expedition/northern-lights-explorer

Cunard: Norway and Northern Lights
www.cunard.com/en-gb/cruise-destinations/northern-lights

Havila: Round Voyage
www.havilavoyages.com/voyages/round-voyage-bergen-kirkenes-bergen

Hurtigruten: Astronomy Cruise
www.hurtigruten.com/en-gb/offers/northern-lights-promise

Quark Expeditions: Arctic Expeditions
www.quarkexpeditions.com/expeditions#arctic

Saga: Norway and the Northern Lights
travel.saga.co.uk/cruises/ocean/where-we-go/norway-cruises

Viking: In Search of the Northern Lights
www.vikingcruises.co.uk/oceans/cruise-destinations/specialty/northern-lights/index.html

Follow satellite data for a real-time heads-up when the solar wind surges

Predicting the aurora

In the far north, substorms are your best clue

Aurora forecasting can be done with precision – if you know how. However, the Kp index – one of the main metrics for predicting aurorae – is of limited use if you're already in the auroral oval.

The Kp index, measured on a scale from 0 to 9, refers to the intensity of any aurora and how far south the auroral oval might stretch. That's useful in the UK and North America, but not in more northerly regions, where aurorae can and do appear during Kp 0 conditions.

There, it's more helpful to watch data from the DSCOVR and ACE satellites, which give about 40–60 minutes' warning of what the solar wind is doing. Available on apps like Glendale Aurora Alerts (www.aurora-alerts.uk), the key real-time data to watch is the nanoteslas (nT) at your location. This determines whether a substorm is imminent – a sudden, intense disturbance in Earth's magnetosphere – and that means visible aurorae.

When the nT figure is negative and dropping sharply – a state known as 'growth' – it indicates that energy from the solar wind is building in the magnetosphere. "There's an increase in the likelihood that magnetic reconnection events are going to happen," says Kerss.

When apps like Glendale say 'expansion', this energy is being rapidly released, causing aurorae around the Arctic Circle. When the nT number rises, it's in the 'recovery' phase, meaning the system returns to a quiet state – the aurora is over.

Catching fast, fleeting, unpredictable meteors takes serious sky-watching power: that's where volunteers come in

JUAN MARIA COY VERGARA/GETTY

Meteor hunters unite!

Meteor showers are always awe-inspiring, but now amateur data is helping us track, understand and even protect ourselves from these cosmic invaders. **Mark McIntyre** explains how you can join in

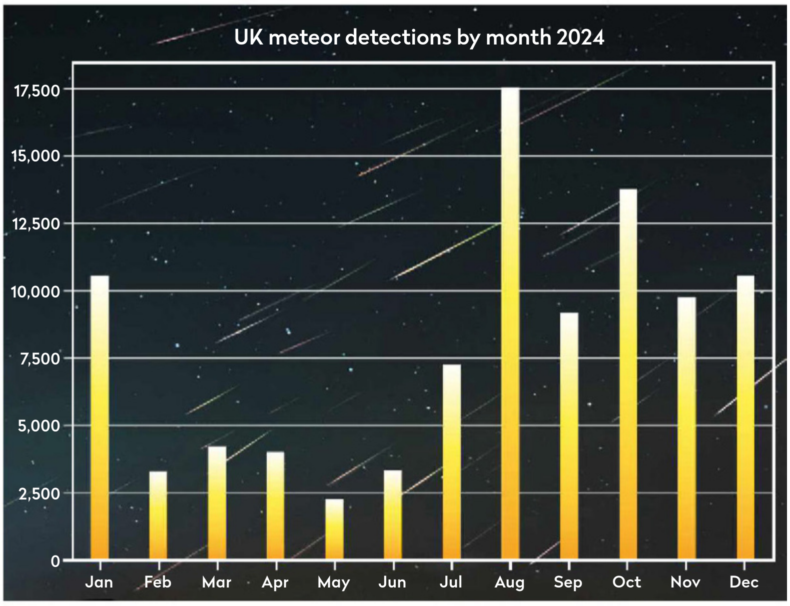
We all love watching meteor showers like the Perseids in August. These dramatic events are one of the easiest astronomical events to observe because they're regular, you don't need to travel to see them and they require nothing more than your own two eyes – and a comfortable chair!

However, many amateur astronomers are now taking their sky watching up a level by recording meteors during showers and reporting their observations to organisations like the British Astronomical Association (BAA), Global Meteor Network (GMN) and the UK Meteor Network (UKMON). So, why are they doing this?

Collecting meteor data is a great way to get involved in science that has real-world implications. Data from amateurs has helped us protect spacecraft and astronauts, locate meteorites, explore the origins of life on our planet and reveal new information about the early Solar System. It's even keeping Earth safer from hazardous asteroids.

And it's now easier than ever. Scientists have been studying meteor showers for centuries, but in the last 20 years or so, new technology has made amateur contributions much simpler. At the same time, government research funding has increasingly targeted 'big science' – like particle colliders and space missions – while meteor science, being an 'established science', is the poor cousin. That's why contributions from amateurs are vital – they're driving the science forward and supplying much of the data that researchers rely on today. ▶

▶ What's more, those amateur contributions come from all over the world, from the Arctic to the Antipodes and from city centres to remote deserts. This allows scientists to have a global picture and to take into account weather and light pollution. We can also monitor events over long distances. For example, in 2024 an 'Earth-grazing' meteor travelled around 900km (560 miles) across the whole of Europe, from Croatia to the UK.



▲ **A year of meteor detections recorded by the Global Meteor Network, all thanks to amateur sky watchers**

Join the great meteor hunt

Naked-eye observing is a great starting point. During meteor showers, you can record the number of meteors you see each hour and send a report to the BAA or SPA (contact them via **www.britastro.org** or **www.popastro.com/meteor**). Visual observations are still important as we can compare them to historical data to study how light pollution or climate change might be affecting observations. And if you see a fireball, you can make a more detailed report via the SPA website at **www.popastro.com/meteor/report-a-sighting**, where you can add the direction of travel, brightness, whether it made a sound, and more. This information is collated globally.

However, to turn your watching into a truly scientific pursuit, switch to using video (see below). For a relatively modest amount of money, you can get a camera that is more sensitive than the human eye and that automatically uploads to GMN or UKMON. The software that operates the video camera can even be used to analyse dashboard and doorbell camera footage of fireballs – though that's an advanced technique!

Apart from video systems like these, you can sometimes detect meteors with an all-sky camera. However, most budget all-sky cameras have quite low resolution and sensitivity, and so only pick up the brightest events. If you want an all-sky camera capable of detecting fainter events, it's a lot more expensive. You can find more information on the different types of cameras on the UK Meteor Network's website, linked at the end of this article.

Finally, meteors can be detected by radio. This works like radar, bouncing a radio signal off the hot air surrounding a meteor. The reflection is detected using simple homemade equipment, though unlike video you don't get any pretty pictures. However, radio detection has the advantage that it works even on cloudy nights and during the day, so it's a valuable

Track meteors from your own home

Using free software and a security camera, you too can start scanning the skies

If you want to step up from visual observing, the simplest way is with the Raspberry Pi Meteor Software (RMS). RMS is a free, open-source program that runs on a Raspberry Pi or Linux PC and uses a cheap security camera to take video of the night sky. It is almost fully automated and will run every night without human intervention. The cameras have a very wide field of view – about 90° by 45° – and are very sensitive in low light, which makes them ideal for meteor hunting as they can pick up meteors up to five times fainter than the human eye can detect.

The software can be downloaded via the link below, where you'll also find instructions on how to build the camera and the other parts you will need. Once your station is running, it will automatically start up at dusk each day, watching for meteors and reporting them to GMN the next day. You can review your camera's data on the GMN website and you can also look at it on the Pi, using tools that come bundled with RMS.

There's more about RMS and the required hardware on the UK Meteor Network's website at **www.ukmeteornetwork.org/want-a-camera**.

The eye that never sleeps: a low-cost camera can watch the sky for you all night

HAITONG YU/GETTY, MARK MCINTYRE X 3, PETE LAWRENCE X 2, NASA/STSCI

◀ **Pricey but powerful, all-sky cameras capture a wide field of view and can even help pinpoint where meteorites land**

addition in its own way. You can even build your own radio detector; there's more information about such a project on the Society for Popular Astronomy's website.

So, there are lots of ways to record meteors and, using these methods, more and more amateurs are capturing useful data in large volumes. In the UK alone, there are now more than 250 video cameras and dozens of radio detectors in operation. Worldwide, the number of amateur observers contributing to meteor research stretches into the thousands.

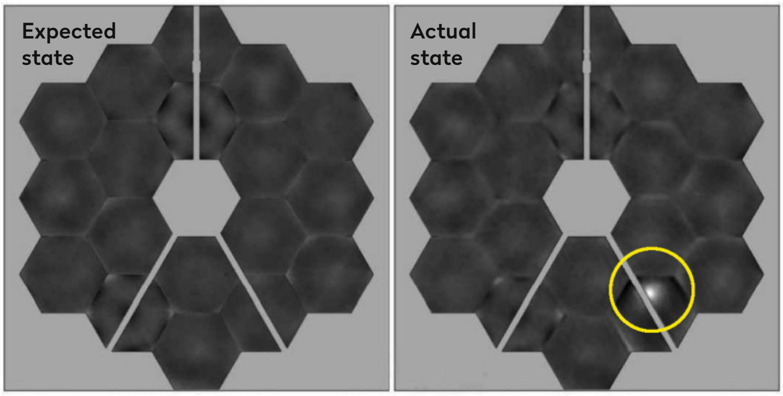
But amateur contributions aren't just limited to collecting data. You can do some research of your own, using data that's accessible from the IMO, GMN and UKMON websites. For example, if you're located in the UK and witness a bright fireball, you can check to see if anyone else with a camera detected it and download any available data to work out more about the meteor. In fact, the scientific community relies heavily on amateurs to let them know about interesting events because there aren't enough scientists to deal with the data volume.

Using amateur data, we can measure how much meteor showers are changing. Most meteor showers originate from comet dust (see 'What makes a meteor shower?', overleaf) but the gravity of the Sun and planets changes the dust's orbit over time, causing changes in the date of the peak or the number of meteors per hour, or even splitting showers in two.

"The scientific community relies heavily on amateurs because there aren't enough scientists to deal with the data volume"

UK008A 2023-12-15 01:39:13 UTC

▲ **A Geminid fireball videoed in December 2023 by an Edinburgh-based member of the UK Meteor Network, using Raspberry Pi Meteor Software**

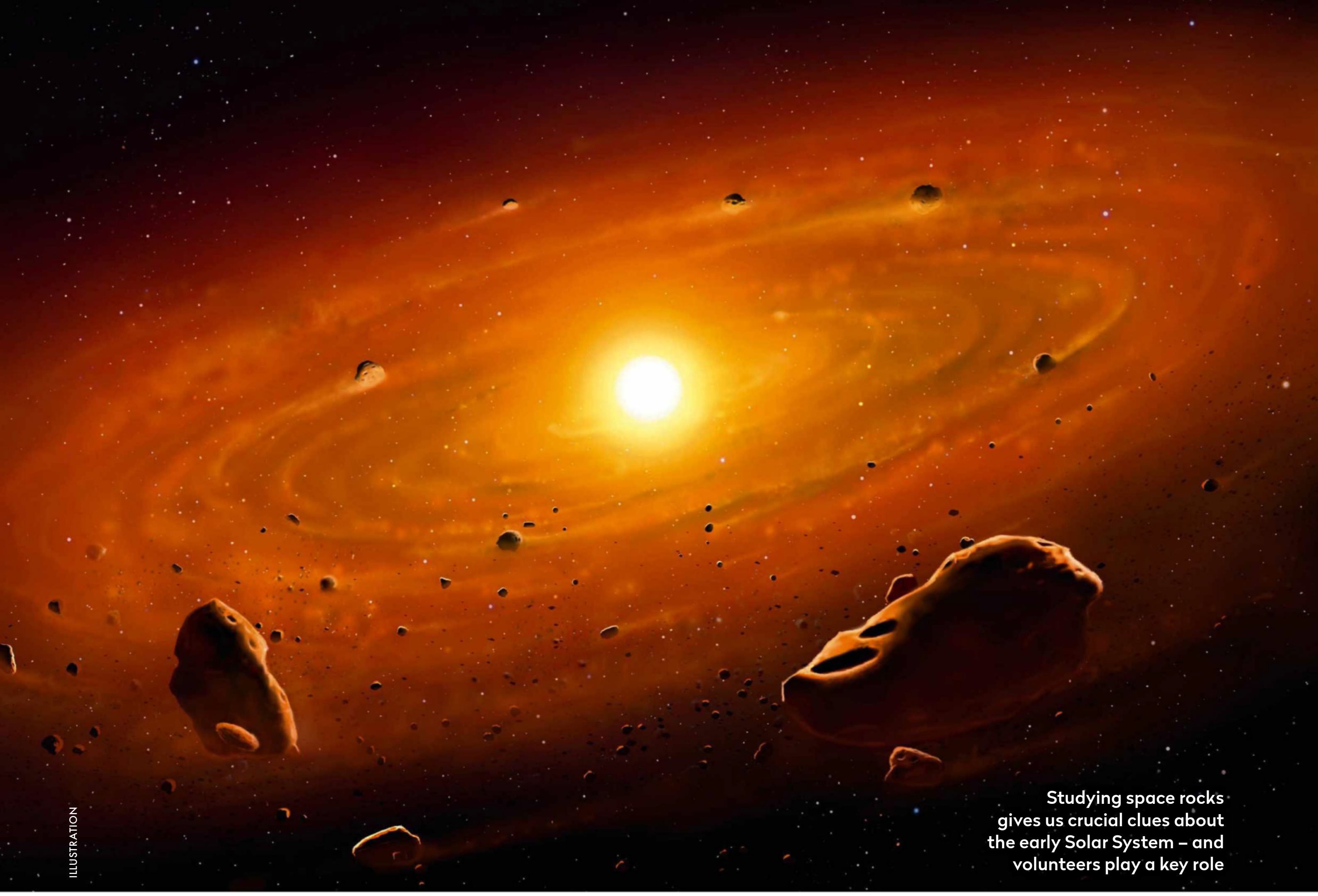


▲ **Bruising encounter: in May 2022, a micrometeoroid chunk bigger than scientists had prepared for struck the JWST, damaging one of its mirrors (right)**

Amateur data helps save lives

This is where spacecraft protection comes in. Meteors can punch right through an unprotected spacecraft – or spacesuit, for that matter. Even the mighty JWST was damaged when a meteoroid struck one of its mirrors shortly after launch. Because of the risk, some space agencies now use amateur data to help decide when a spacewalk is safe, how to reorient satellites during showers, and in the design of shielding for new spacecraft. As Denis Vida from GMN said, "[Our] data is operationally used by NASA's Office of Safety and Mission Assurance". And that's pretty cool.

The data is also being used for planetary defence. This might sound a bit grandiose, but studying meteors helps scientists to understand the chances of larger objects reaching Earth and to work out how they'll behave in our atmosphere. An example of this is asteroid 2023 CX1, which was recorded by amateur networks as it entered Earth's atmosphere and burned up over France. Analysis of the data led ▶



ILLUSTRATION

Studying space rocks gives us crucial clues about the early Solar System – and volunteers play a key role

“The data contributes to our understanding of the evolution of our Solar System and has helped in the identification of several new meteor showers”

Many people spotted asteroid 2023 CX1 before it struck the ground in northern France

MARK GARLICK/ALAMY STOCK PHOTO, WOKEGE, JOHN WHITE PHOTOS/GETTY, FIREBALLS AOTEAROA

▶ to its orbit and trajectory being calculated, and this led to meteorites being found on the ground in France. Now we know what type of rock it was and where in space it came from. A forthcoming paper will also explain how it behaved in Earth’s atmosphere, how the energy was dissipated and what that might mean for larger asteroids.

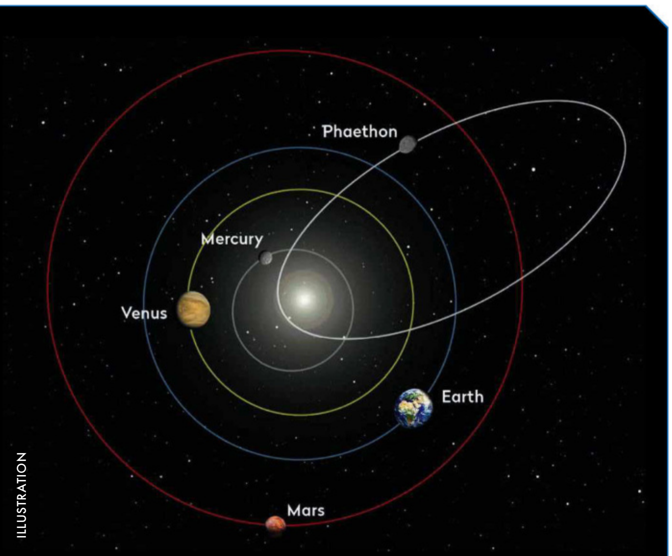
The data also contributes to reshaping our understanding of the evolution of our Solar System. Data gathered by amateurs has helped in the identification of several new meteor showers and brought fresh insights into the behaviour of asteroids and comets. For example, a new shower was recently discovered in Puppis using data collected by GMN and analysed by a team of professionals and amateurs working together.

But the research isn’t just limited to our Solar System. Data collected by amateurs is also being used to search for extrasolar meteors. These objects from outside our Solar System are difficult to identify because we only see them once they’re passing through. Their fleeting nature makes them hard to confirm, but by analysing the huge volume of amateur data, scientists can improve their chances of finding one and refine their ideas of what to look for.

Find your own meteorite

Of course, amateurs are central to meteorite recovery. In the last few years, a dozen or so meteorites have been recovered using amateur data to identify the ‘fall zone’, and amateurs are often

▲ 2007's majestic Comet McNaught: as comets near the Sun, they shed debris – material that can later make meteor showers



▲ Asteroid 3200 Phaethon orbits searingly close to the Sun. How this rocky body creates December's Geminids remains a mystery

What makes a meteor shower?

Dust left in space by comets and asteroids ends up as streaks of light in our skies

We've all seen pictures of comets, their dusty tails stretching across the sky. Those tails form because comets are made of dust and ice; when they get near the Sun, the ice melts, releasing some of the dust into space. Over time, this creates a dusty trail along the comet's path around the Sun. When Earth passes through that trail, some of the dust enters our atmosphere and burns up, producing a meteor shower. For example, we pass though dust from Halley's Comet twice each year, giving rise to the Eta Aquariids in May and the Orionids in October.

Most of the well-known showers are caused by comet dust, but there's one exception: the Geminids. Their source is believed to be asteroid 3200 Phaethon, rather than a comet. How can an asteroid create a meteor shower? One theory is that Phaethon is an 'active asteroid' with a halo of dust around it being dislodged from the surface. Another is that it might be the core of a comet that has lost all its ice. We aren't sure yet!

▶ **New Zealand's citizen scientists tracked down and recovered the Tekapo meteorite in 2024**

on the ground searching. In the UK, the UK Fireball Alliance, UKFall, has coordinated several meteorite searches – in fact, as this article was being written, news broke of another possible UK meteorite fall – while organisations in other countries are doing similar work. For example, the Tekapo meteorite that landed in New Zealand's South Island was recovered in 2024 using amateur data and an amateur search team. You can read more about this here: **bit.ly/meteorsci4**. As Ashley King of UKFall and London's Natural History Museum said, "the more cameras we have, the more fireballs we see and the more meteorites we recover!".

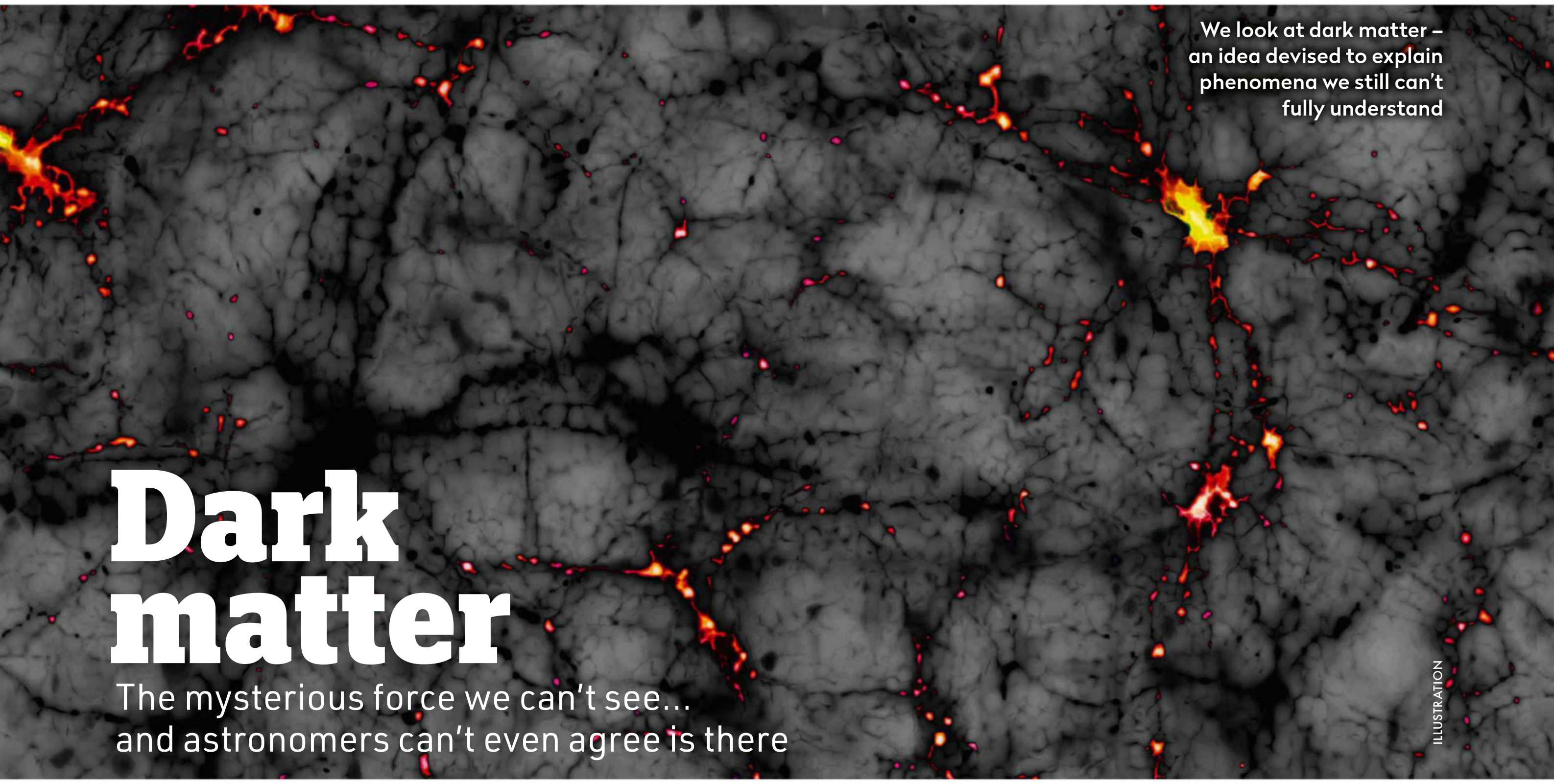
The data isn't only used to study meteors. The same information is now being used to study variable stars and novae, rocket booster and satellite re-entries, and even climate change. So, as you can see, amateurs play a crucial and fascinating role in the study of meteors and meteorites – and more – and are helping scientists better understand the Solar System, how to defend our planet, and improve spacecraft and astronaut safety.

If this article has piqued your interest, you can find out more on the UK Meteor Network's website at **www.ukmeteornetwork.org**.

Mark McIntyre is an astrophysicist, meteoricist and astrophotographer, and a member of the UK Meteor Network

The fundamentals of astronomy for beginners

EXPLAINER



We look at dark matter – an idea devised to explain phenomena we still can't fully understand

ILLUSTRATION

Dark matter

The mysterious force we can't see… and astronomers can't even agree is there

Our eyes paint such vivid portraits of the world around us that it's easy to forget how much of our surroundings go unseen. Wi-Fi signals pinging this way and that, subatomic particles and radiation zipping about. And, if astronomers are to be believed, there's another invisible interloper to throw into the mix: dark matter.

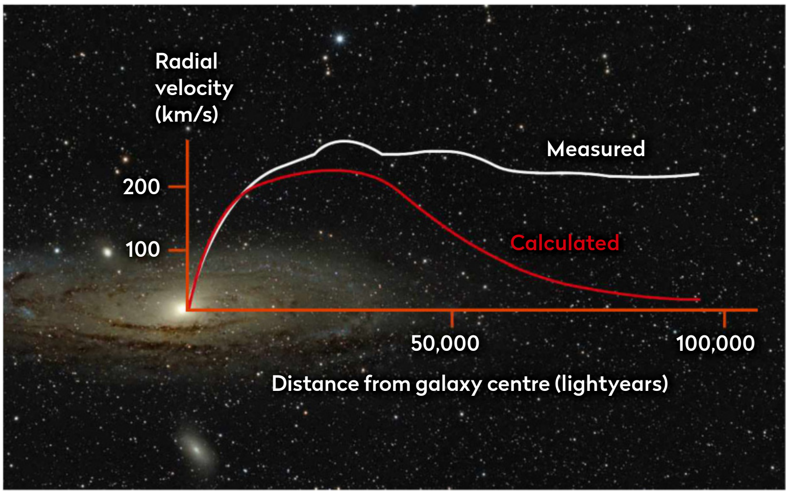
A cosmic glue thought to help bind the Universe together, dark matter is so prevalent that about a milligram (3.5oz) will pass through your body throughout your life. But where did this notion of 'dark matter' come from?

Its story starts in the 1930s. Astronomer Fritz Zwicky was measuring the speeds of galaxies within a big group called the Coma Cluster. He found many were moving so fast that he would have expected them to break free of the cluster's gravitational shackles and head off on their own. Curiously, they didn't. Zwicky suggested there might be some extra, invisible stuff in the cluster providing an additional gravitational glue. Zwicky called this stuff *dunkle materie* – dark matter.

Around the same time, the Dutch astronomer Jan Oort was observing stars on the outskirts of our own Milky Way Galaxy. He also found them to be moving faster than expected, meaning they too should be able to break away. But again, they didn't.

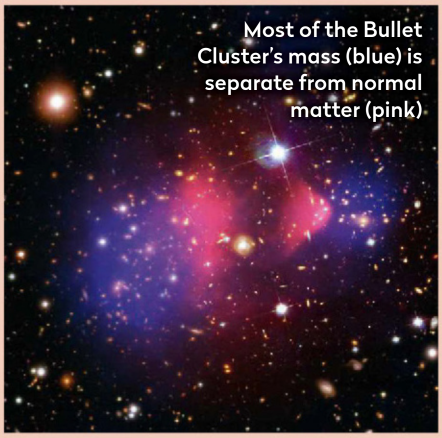
These two key findings were largely overlooked until the 1970s, when US astronomer Vera Rubin picked up the proverbial baton. By 1980, Rubin was ready to publish detailed observations of 21 galaxies.

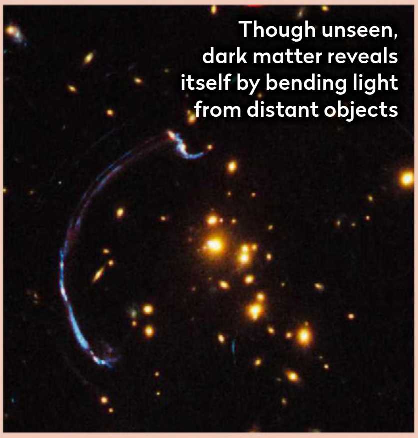
▼ The rotation problem: stars at the edge of galaxies orbit much faster than predicted



Dark matter's smoking gun?

Lensing around one cosmic collision shows something invisible must be at play


Most of the Bullet Cluster's mass (blue) is separate from normal matter (pink)


Though unseen, dark matter reveals itself by bending light from distant objects

The Bullet Cluster is two separate groups of galaxies entwined in a calamitous collision. The enormous energies involved in the clash have superheated the gas within the galaxies, producing copious amounts of X-rays. However, as well as being able to observe these X-rays, astronomers can also work out where most of the cluster's mass is located, using a technique called gravitational lensing.

They discovered that most of the mass is not in the same places the X-rays are coming from – it is separated from the gas. If the galaxies were made of ordinary matter alone, most of the mass would be where most of the gas is. Instead, the usual explanation is that the dark matter in the two galaxies silently passed through the gas, leading to the clear separation.

For advocates of Modified Newtonian Dynamics (MOND), the Bullet Cluster presents a challenge and, while they have tried to get their theory to fit, most astronomers see the cluster as evidence in favour of dark matter.

She found the same thing – that stars on the edges of these galaxies were orbiting too fast – naming this discrepancy 'the rotation problem'.

It's a problem because galaxies don't seem to behave like our Solar System. Move outwards from the Sun and the speeds of the planets wane as the strength of the Sun's gravity drops off. The same thing doesn't appear to be true for galaxies – far-out stars spin around the galaxy at similar speeds to those much closer-in.

The most widely accepted solution to the rotation problem is that what we see as a galaxy is merely a light dusting of visible material on top of a gargantuan scaffold of invisible dark matter.

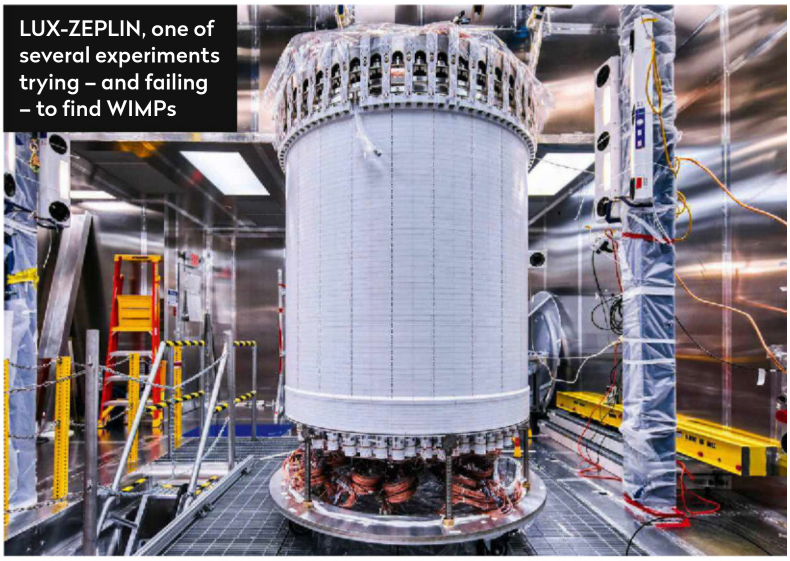
What – and where – is it?

Around 90 per cent of a galaxy's mass is thought to consist of dark matter. With this spread throughout the galaxy, gravity doesn't drop off in the same way that it does in the Solar System, and so the speeds of the stars observed by Zwicky, Oort and Rubin don't drop off either.

Except if dark matter really does outnumber the ordinary matter that stars, planets and people are made of by 9:1, surely we should be able to find it?

A big part of the puzzle is working out what dark matter is actually made of. Astronomers wondered whether it could be a conglomeration of heavy, invisible objects like black holes and planet/star hybrids known as brown dwarfs – but there simply aren't enough of them.

The most fashionable idea in recent decades suggests that dark matter is made of Weakly Interacting Massive Particles (WIMPs), but astronomers and physicists have never seen one, despite exhaustive – and expensive – searches.


LUX-ZEPLIN, one of several experiments trying – and failing – to find WIMPs

Colin Stuart (@skyponderer) is an astronomy author and speaker. Get a free e-book at **colinstuart.net/ebook**

A completely different idea is that dark matter is a figment of our collective imaginations. Instead, a theory called Modified Newtonian Dynamics (MOND) argues that gravity itself works differently on the scale of a galaxy compared to the scale of the Solar System. Only by applying the wrong set of rules to the wrong situation does it look like the stars are moving too fast.

However, this notion too is contested, particularly as a group of galaxies called the Bullet Cluster is usually held up as significant evidence against MOND (see above).

So, for now, the true nature of dark matter remains a confounding mystery, one of the biggest in all of astronomy. When it comes to knowing what the Universe is really made of, astronomers are still well and truly in the dark.

MARK GARLICK/SCIENCE PHOTO LIBRARY/ALAMY, CCDGUIDE.COM, X-RAY: NASA/CXC/CFA/M.MARKEVITCH ET AL/OPTICAL: NASA/STSCI/MAGELLAN/U.ARIZONA/D.CLOWE ET AL/LENSING MAP: NASA/STSCI/ESO WFI/MAGELLAN/U.ARIZONA/D.CLOWE ET AL, ASA/ESA/J. RIGBY (NASA GODDARD SPACE FLIGHT CENTER) K. SHARON (KAVLI INSTITUTE FOR COSMOLOGICAL PHYSICS/UNIVERSITY OF CHICAGO) M. GLADDERS AND E. WUYTS (UNIVERSITY OF CHICAGO) AND THE HUBBLE HERITAGE TEAM (STSCI/AURA), MATTHEW KAPUST/SANFORD UNDERGROUND RESEARCH FACILITY

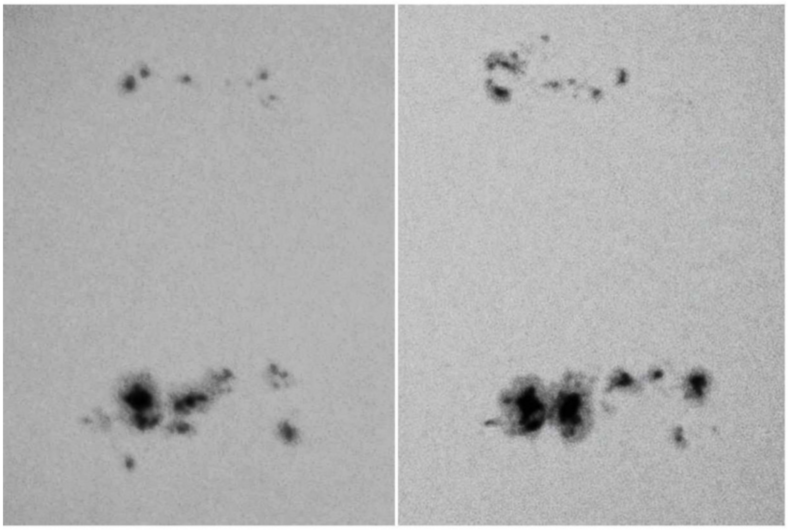
CAUTION
Never observe or image the Sun with the naked eye or any unfiltered optical instrument

Practical astronomy know-how for every level of expertise

SKILLS FOR STARGAZERS

Track and measure sunspots

How to find, follow and analyse these dynamic features on our ever-changing Sun



▲ **An active region of sunspots captured in February 2014 (left) and how it had changed three days later (right)**

The Sun's surface often looks speckled with darker regions. These are sunspots – cooler patches that form as a result of the Sun's complex magnetic field preventing heat from reaching localised areas of the photosphere. How many you'll see varies during the 11-year solar cycle, with greater numbers during solar maximum – which we're in right now.

Humans have been observing sunspots for centuries, but we have only tracked them in detail since the telescope was invented. Originally, this meant projecting through the telescope onto a piece of white card and sketching the result. These days, observing and photographing the Sun is done either with a certified solar filter on the front of a telescope or a Herschel wedge on the back of a refractor.

Sunspots are related to intense magnetic activity and are often associated with solar flares and coronal mass ejections. These in turn are responsible for geomagnetic storms on Earth. While these produce stunning aurorae, they also impact spacecraft, satellites and infrastructure like the power grid, as well as the health of pilots and astronauts.

Check for spots

This is why solar activity is monitored constantly, not just by ground-based observations here on Earth but also via satellites such as the Solar Dynamics Observatory (SDO). The multi-wavelength images that the SDO creates are freely available to download, so you can measure, track and analyse sunspots even if you don't have a telescope.

If you do have a telescope, the SDO images will help you to identify sunspots you've detected and correct any orientation differences, mirroring or inversions caused by your telescope optics. You can then track the sunspots as they move as the Sun rotates; they typically take about 12 days to travel across the disc.

Sunspot morphology can change over just a few hours. To monitor changes, you'll need to accurately measure sunspot sizes. You can do this manually, by measuring the apparent diameter on an image compared to the known diameter of the Sun. However, this method is crude and doesn't allow for the foreshortening effects seen around the edges of a spherical body.

To get more accurate measurements of sunspots near the limb, use the Solar Ruler produced by Gustavo Joaquín de la Piedra Lira (link below), which has concentric rings that take this foreshortening into account. Each division of the outer ring represents 50,240km (31,218 miles), there is an Earth/Jupiter diameter scale comparison and an Earth-to-Moon distance for reference.

While photographs are recommended for this project, visual solar observation and sketching still play a valuable role. This is because modern cameras can detect sunspots too small to be seen with the naked eye, leading to higher sunspot counts in recent solar cycles compared to historical visual records.

Mary McIntyre is an outreach astronomer and teacher of astrophotography

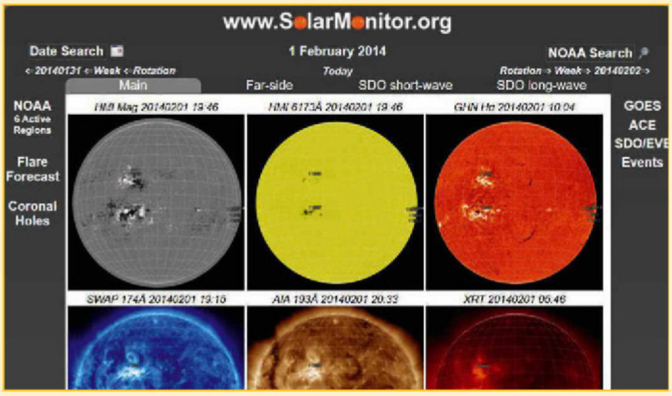
FREE BONUS CONTENT
Download Gustavo's Solar Ruler from www.skyatnightmagazine.com/bonus-content

What you'll need

- Full-disc images of the Sun taken several days apart. Ours were taken three days apart with a DSLR on a 70mm refractor fitted with a glass solar filter
- Visit **www.solarmonitor.org** to download a reference image against which you can align your own photos or identify sunspots
- Gustavo's Solar Ruler (see link above)
- Photoshop, GIMP or similar software that allows you to paste and move layers and change their transparency

ALL PICTURES: MARY MCINTYRE

Step by step


www.SolarMonitor.org
Date Search
1 February 2014
NOAA Search
« 20140131 « Week « Rotation
Today
Rotation » Week » 20140202 »
Main
Far-side
SDO short-wave
SDO long-wave
NOAA 6 Active Regions
Flare Forecast
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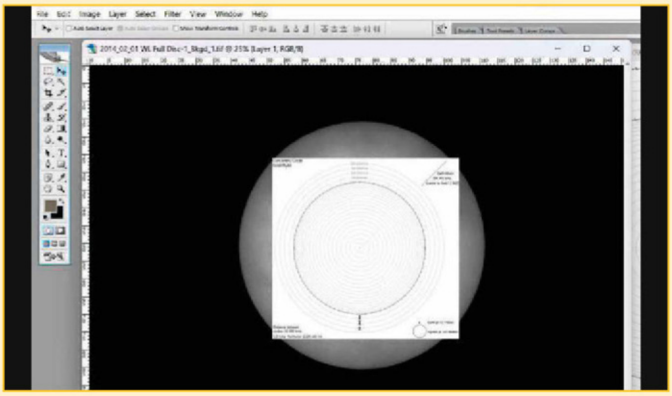
SWAP 174Å 20140201 19:15
AIA 193Å 20140201 20:33
XRT 20140201 06:46

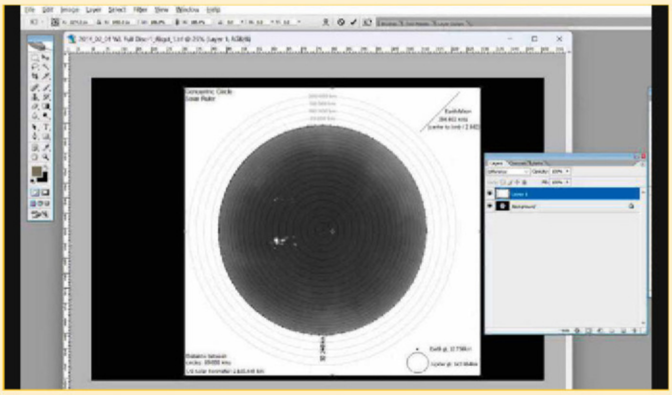
Step 1

Go to **www.solarmonitor.org**; input the date in the Date Search box. Select the 'HMI 6173Å' image to see the photosphere version of the solar disc. Use this to align your camera before imaging or as a reference to correct images that you've already taken.



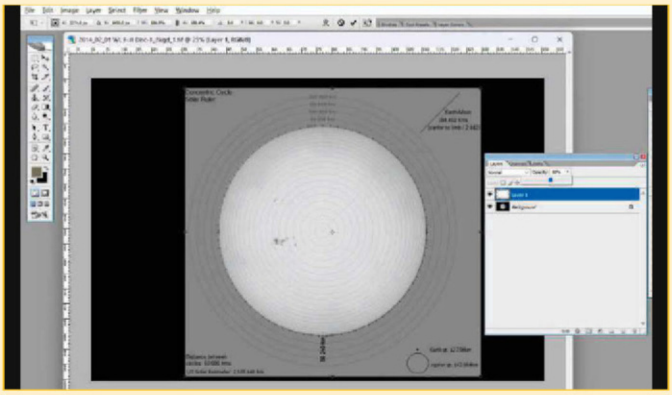
Step 2

Download Gustavo's Solar Ruler. Open it with Photoshop, along with your Sun disc image. Click on the Solar Ruler, use Ctrl + A to select all, then Ctrl + C to copy. Click on your Sun image and use Ctrl + V to paste the Solar Ruler as a new layer on top.



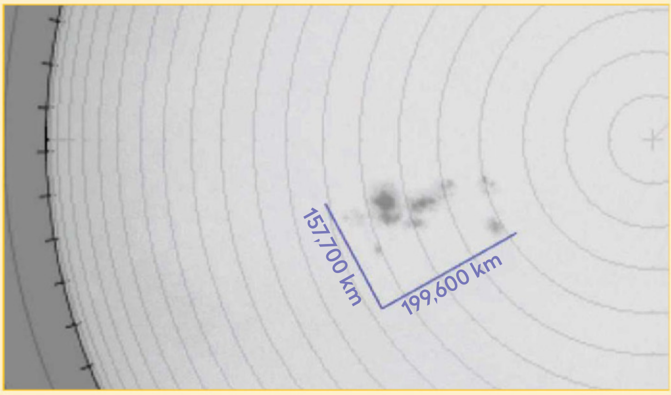
Step 3

Go to Layers and set the mode to 'Difference' to see both layers at once. Click Edit > Free Transform. Click the 'lock ratio' button at the top, then drag the corners of the Solar Ruler image until the outer circle perfectly aligns with your Sun image. Click Enter.



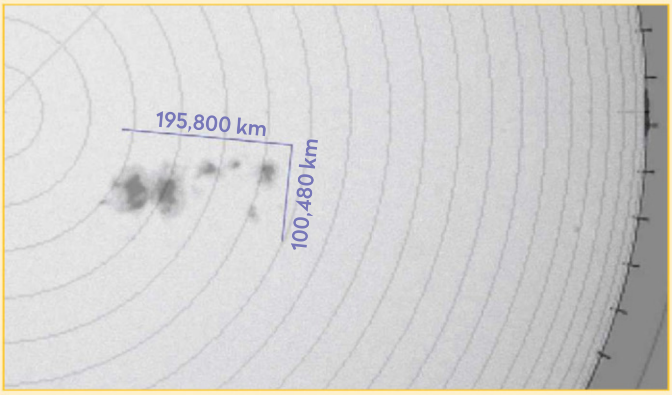
Step 4

Set the layer mode back to 'Normal' and move the transparency slider until you can clearly see the detail in both layers; we set ours to 60 per cent. Right-click either of the layers, then select 'Flatten image' to merge them. Save the image with a new name.


157,700 km
199,600 km

Step 5

Zoom in on the merged image and use the concentric rings and a ruler to measure the length and the outside markings for the width of the sunspot region. Our sunspot group measured 199,600km x 157,700km. You can also measure individual spots.


195,800 km
100,480 km

Step 6

Repeat step 5 for images taken on subsequent days. Three days later, our sunspot group measured 195,800km x 100,480km. You can also record the morphology changes in whole groups or in individual sunspots over time.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

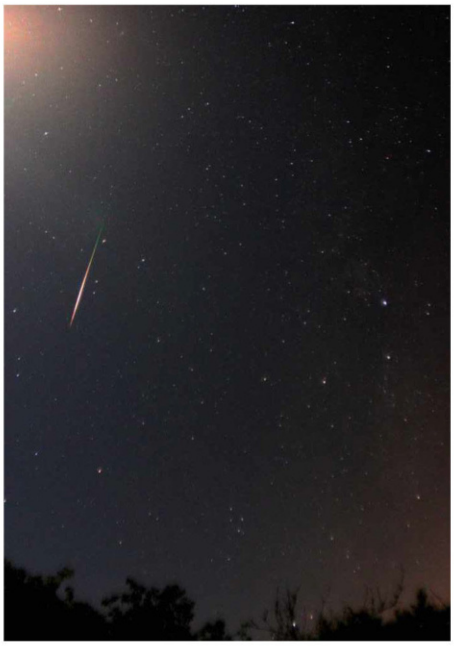
Moonlight Perseids

The Moon will be a nuisance, but you can still get great meteor shots – here's how

Whichever way you look at it, this year's Perseid meteor shower peak on 12 August is going to be challenging for naked-eye observers. As with all meteor showers, some years are better than others, but this year, there's a large bright Moon near the position of the radiant to contend with.

As a consequence, we have to be adaptable and adjust to conditions when they arise. There's not a lot we can do about the weather, but there are ways to get observational results even under difficult conditions like strong moonlight.

While moonlight significantly hampers visual observing, its impact on meteor photography is somewhat different. Essentially it causes two main issues: a) it over-exposes the area of sky near the Moon and b) it limits how long you can expose other areas of the sky if you want to avoid over-exposing those too. However, consider what happens when a meteor trail bright enough to record appears. The light from the trail traces a line across your camera's sensor in typically less than a second, and that's the trail image done. In theory, at this point, if you were watching the shower and noted the trail, you could stop the exposure immediately to minimise the effect of moonlight on the rest of the image.



▲ **Moon vs meteor: a Perseid meteor captured with a 70%-lit waning gibbous Moon high in the sky**

Aim for the action

Remember that in meteor photography, you're not looking to get an attractive image of the background sky; you're after a shot of the trail, with perhaps a few bright stars recorded to allow measurements to be taken. In reality, if you could just take exposures when trails occurred this would be the best option. You could eliminate star trails and reduce the number of wasted exposures. Some systems do exist to do this, normally using video capture, where a small, continuous video sequence is held in a camera's memory, say 10 seconds in length. If a trail is detected in the sequence, this is sent to archive storage while the sequence block continues.

In this imaging guide, we're not going to be so sophisticated – quite the opposite. Recognising that we need to keep exposures short, we're going to reduce exposure length to find a point where the sky doesn't over-expose and simply keep taking photo after photo in the hope we'll catch something.

Reducing the exposure comes at a price. When you take shots with a DSLR or equivalent, there's a small delay while the photo is transferred to storage and before the next shot begins. If you're taking continuous 30-second shots one after the other, the gap isn't significant. Let's imagine it's 1 second in length, so every 30-second exposure effectively takes 31 seconds to complete. Therefore, for every 30 minutes of exposure time, approximately 1 minute would be wasted due to the cumulative gaps. Imagine shooting the sky for 1 minute with the lens cap on. It would feel like an eternity – and naturally, that's exactly when the brightest, most spectacular fireball would decide to show up!

Reducing exposure time doesn't reduce the gap interval; it makes the loss more noticeable. One way around this is to use two cameras with their shooting sequences out of sync, so the sky is covered at all times. With a bit of effort, shooting meteors under bright moonlight can be done – and may even yield shots that are a little more exclusive than normal.

Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

Equipment: DSLR or equivalent, wide and fast lens, remote shutter control and a tripod

✉ **Send your images to:**
gallery@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

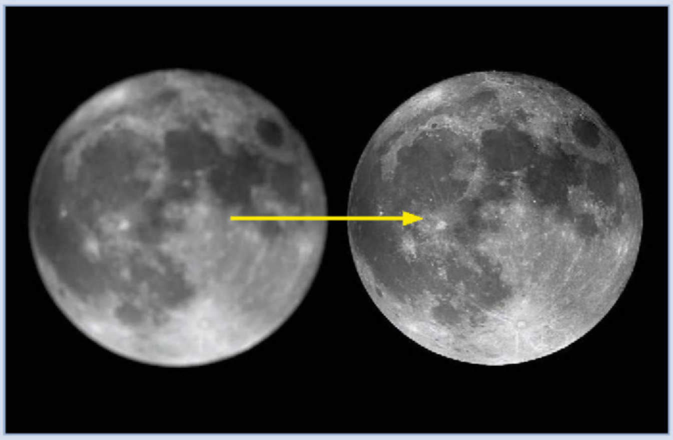
Step by step

STEP 1

A DSLR, MILC or equivalent camera is ideal for meteor photography. A wide-field, fast lens is normally recommended but the presence of a bright Moon relaxes these considerations somewhat. A lockable remote shutter release is necessary for continuous shooting and, of course, you'll need enough storage cards to store several thousand images.

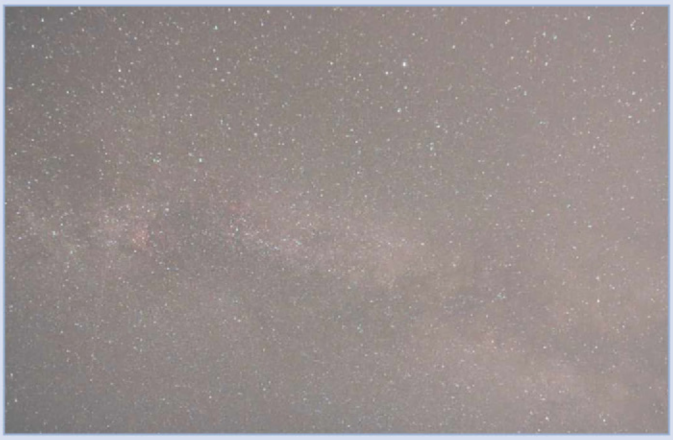
STEP 2

We recommend that you mount your camera on a stable platform, preferably a tripod that will allow the pointing angle to be adjusted. It's important to bear in mind that the sky appears to move relative to a fixed pointing angle – it's highly advisable to adjust where your camera points over the course of the evening, so that the Moon doesn't wander into the field of view!



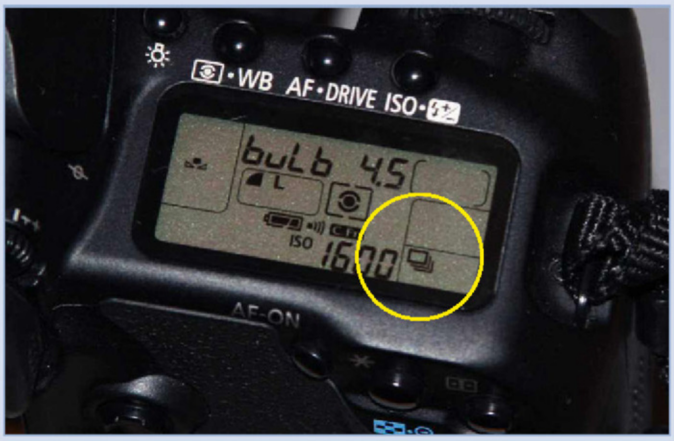
STEP 3

Adjust the lens to be wide open (lowest f/ number) and pre-focus at infinity. Here, the Moon can actually be useful for getting sharp focus. Set your camera's ISO to 1600–3200 but be prepared to lower it if the results in step 4 dictate. Set exposures for 30 seconds and, again, be prepared to reduce that if necessary.



STEP 4

Take a test shot. With such a bright Moon, you're unlikely to get a dark, star-laden image; more likely is one that's daylight-blue with stars. If it comes out white, shorten the exposure, reviewing in between. Avoid going below 10 seconds; if you reach that, begin lowering the ISO. You want visible stars and no white areas.



STEP 5

Point your camera away from the Moon at an altitude of around 60°. Don't block the field of view with large foreground objects – they might look artistic, but they only reduce your chances of picking up a meteor trail. Set your camera to continuous shooting mode, lock the remote shutter button down and let it run.

STEP 6

Keep an eye on the lens and clear any dew with a 12V camping hairdryer. A fit-and-forget solution is to wrap the lens with a band heater, often sold in astro-imaging dew-heater kits; USB versions run from power banks. When the session is over, the fun really begins: looking through each image for meteor trails!

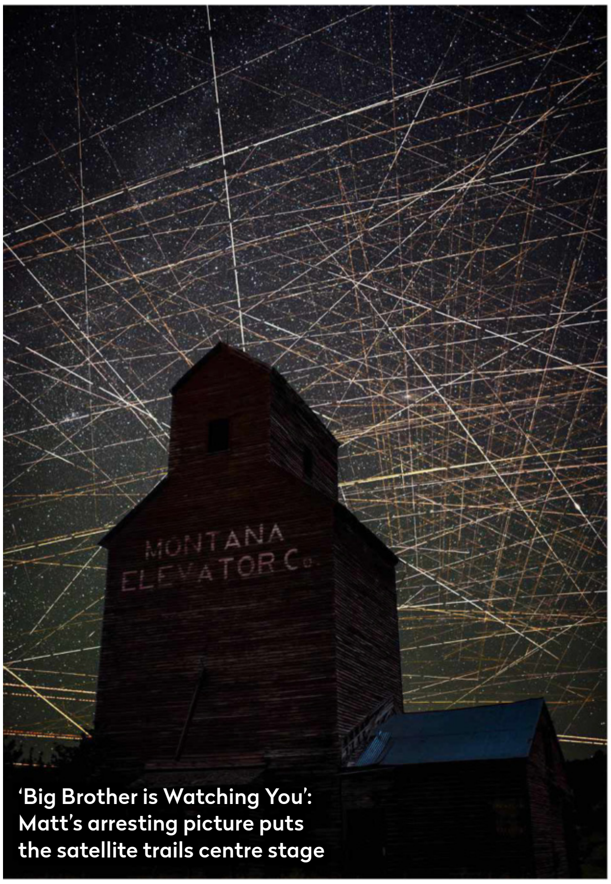
Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

Showcasing satellites

A timelapse composite that reveals our crowded skies

Astronomy Photographer of the Year Advice from a highly commended entrant in 2024's awards


'Big Brother is Watching You': Matt's arresting picture puts the satellite trails centre stage

Since Russia launched Sputnik 1 into low Earth orbit in 1957, thousands of satellites have begun congesting the skies over our planet – something anyone shooting night-sky timelapses will be keenly aware of.

Having spent much of the past five years doing just that, I started considering ways to create a timelapse composite that showcased these satellite trails. Here I'll run through the steps I took to make 'Big Brother is Watching You', my highly commended image in the People and Space category of 2024's APY competition.

I captured the frames for this image in the early evening. Satellites are most visible a few hours before sunset and after sunrise, when the Sun is low enough to darken the skies, but at an angle that its light strikes the satellites. This timelapse comprised one hour of six-second exposures at f/1.4 and ISO 5000.

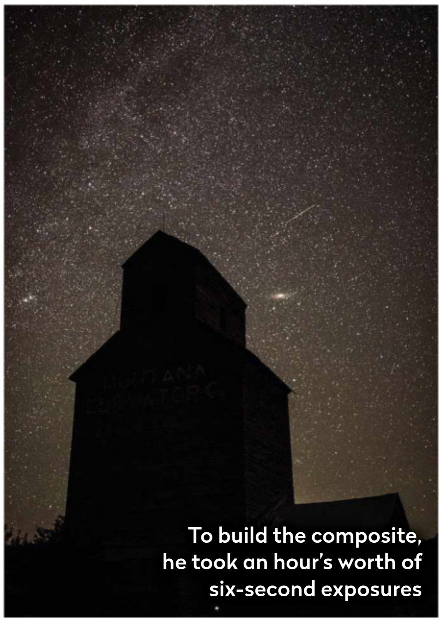
Before creating the timelapse, I batch-edited the frames in Adobe Lightroom. To do this, I headed to the Develop module and edited a single frame to my liking. I chose to increase the prominence of each satellite by moving the Contrast, Whites and Dehaze sliders to the right, and then decreased Shadows, Blacks and Highlights. To apply that to all of my frames, I then selected all remaining frames (Ctrl + A) and synced the settings (Ctrl + Shift + S › check all settings › Synchronize). I then saved the frames as 'Satellite images', ready for Photoshop.

In Lightroom, I also chose a background image for the composite and edited it as desired before saving it separately as 'Background image'. When editing this frame, I made sure the empty sky was lighter than the sky in the satellite images, to make compositing the satellites with the background image easier.

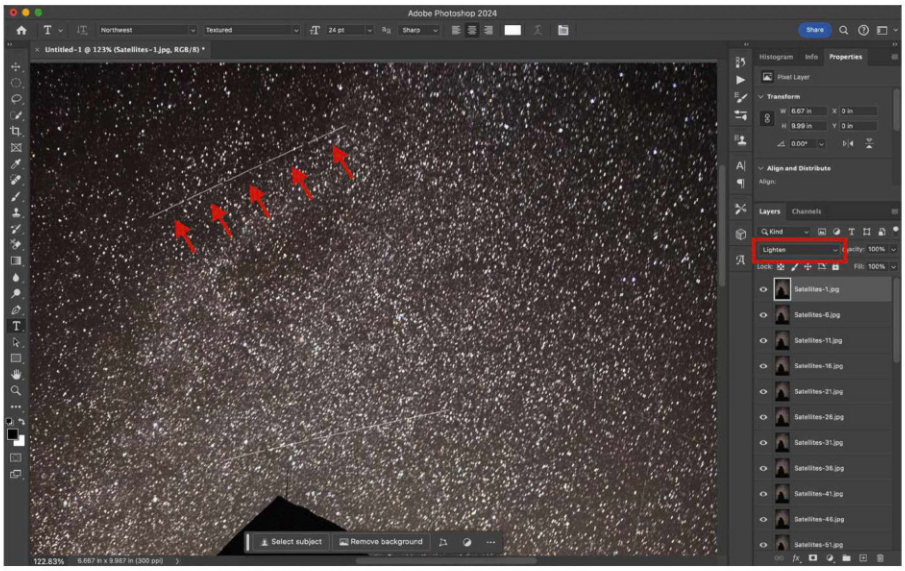
Next, I loaded the 'Satellite images' as a stack in Photoshop (click File › Scripts › Load files into stack › select files), with Layers set to 'Lighten' (see Screenshot 1). I then merged the layers into groups of five by selecting five layers at a time before right-clicking and selecting 'Merge Layers', which reduced the number of layers from 515 to 103. Each satellite then appeared as a streak of five lines, making them easier to find (Screenshot 1).

Mask the layers

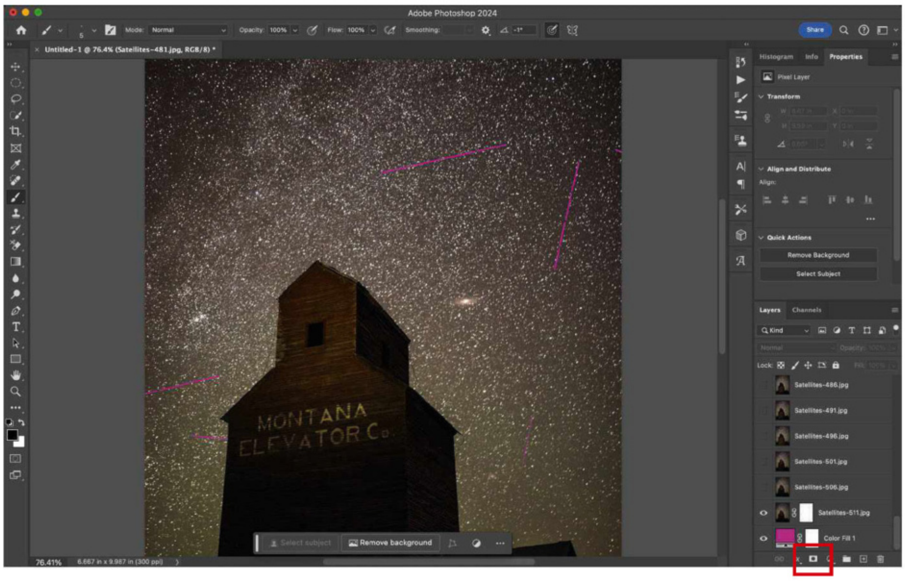
It was then time to select and separate out the satellites in each layer using masks, so that they could be combined with the background image. To do this, I first 'deactivated' all layers except the bottom one, by unchecking the eye symbol next to the others. To make it obvious which satellites I was masking, I used a pink-coloured layer (click Layers


To build the composite, he took an hour's worth of six-second exposures

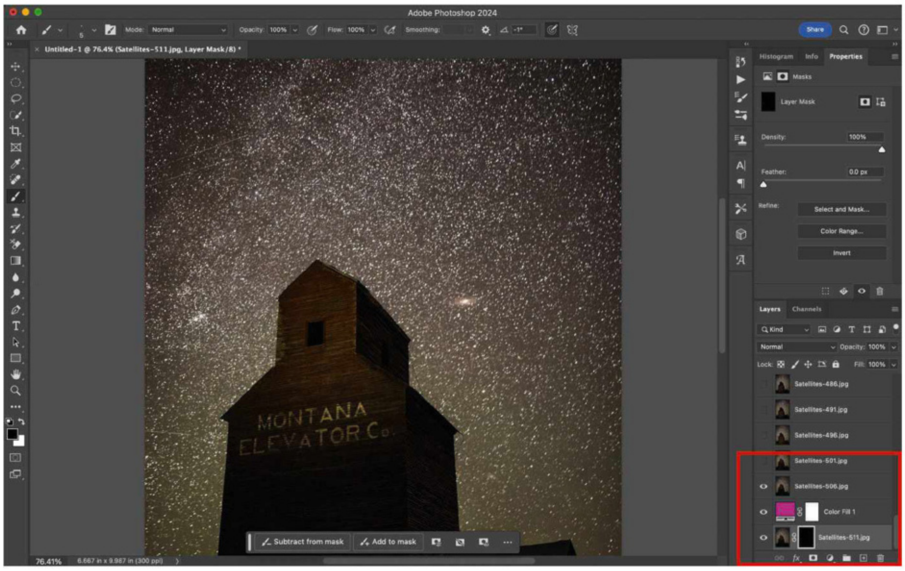
ALL PICTURES: MATT JACKSON



▲ **Screenshot 1: in Photoshop, load your satellite images as a stack, with Layers set to 'Lighten'. Select five layers at a time and choose 'Merge Layers' from the menu to merge them. Each satellite then appears as a streak of five lines, making them easier to find**



▲ **Screenshot 2: with the Brush, click and drag to carefully paint out each satellite streak. Next, invert the mask: this will mask out everything except the satellites in that layer**



▲ **Screenshot 3: repeat this for the rest of the layers: each time, click-drag the pink layer to the layer above, click its eye symbol to reactivate it, then click the mask icon again**

3 QUICK TIPS

1. Use short exposures (2.5–6 seconds), a wide aperture (around f/1.4) and a high ISO (say, ISO 5000) to capture the timelapse.

2. Using a bright-coloured fill layer below the active layer will make masking easier.

3. For mask adjustments, use the square bracket keys to make your brush size larger or smaller.

› New Fill Layer › Solid Color › select pink) before clicking the 'mask' icon (highlighted, Screenshot 2). The pink layer simplifies this masking process by clearly showing the masked satellites.

Using the Brush tool, I carefully masked out each satellite streak by clicking and dragging the brush over each individual streak (Screenshot 2). Once done, I inverted the mask by clicking the mask icon and pressing Ctrl + I simultaneously – this masks everything *except* the satellites in that layer. Using this method is much easier than attempting to mask out everything other than the satellites using the Brush tool. I repeated this for the rest of my layers by clicking and dragging the pink layer to the layer above, clicking its eye symbol to reactivate it, and then clicking the mask icon again (Screenshot 3).

Once all the layers were masked, I deleted the pink fill layer and changed all layers to 'Lighten' again. To complete the composite, I loaded the background image at the bottom of the stack by clicking File › Open › selecting File › Ctrl + C › Ctrl + V and click-dragging it to the bottom of the layer stack. The brighter sky of the background image helped conceal any masking artefacts around each satellite streak. To finish, I made final edits using the Camera Raw Filter (Filter › Camera Raw Filter).

While this process doesn't account for variations in satellite visibility resulting from the time of year and atmospheric conditions, I find that it creates a beautifully arresting image.

Matt Jackson is a research scientist in the water industry. His love for astrophotography began during his PhD

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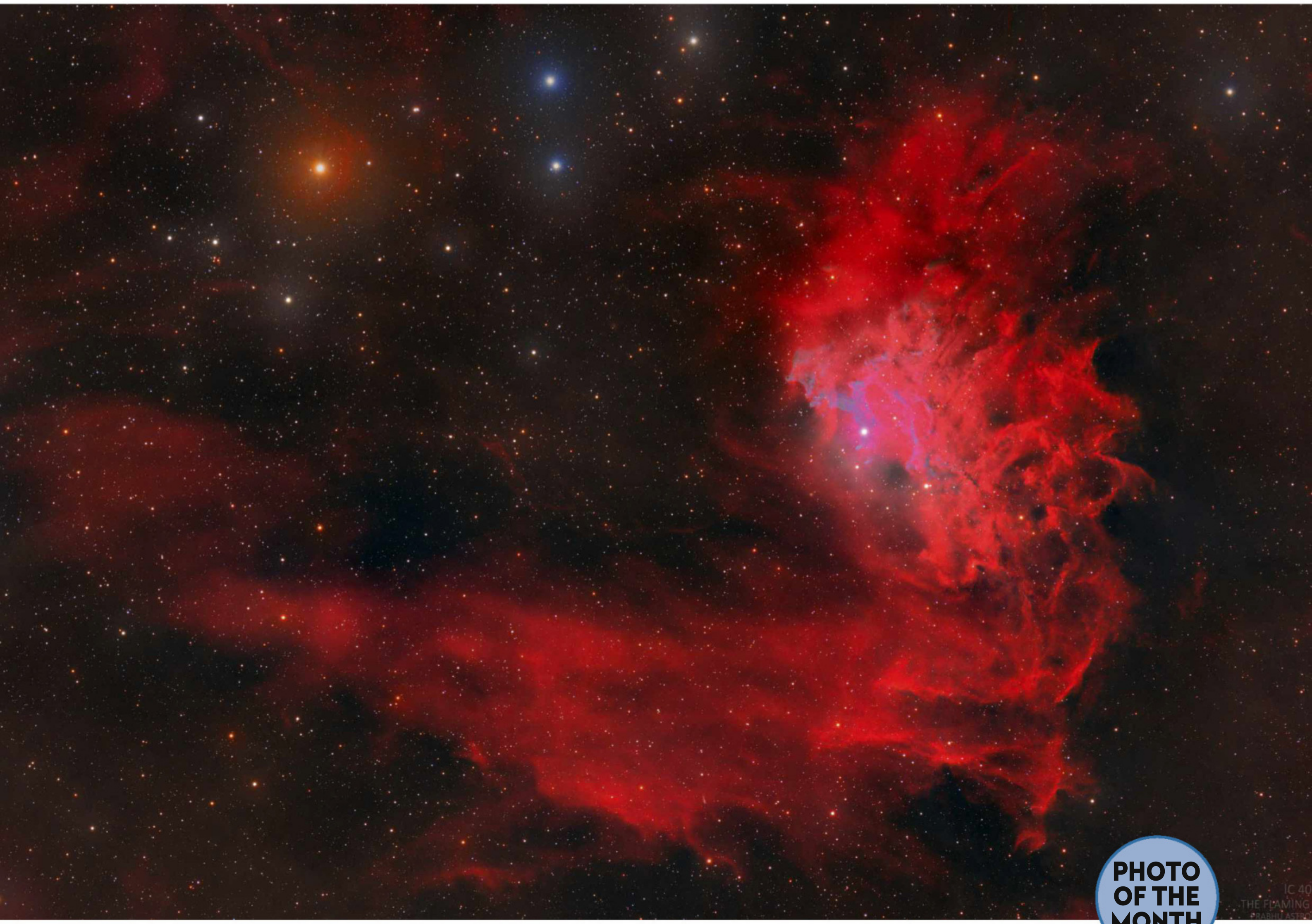


PHOTO OF THE MONTH

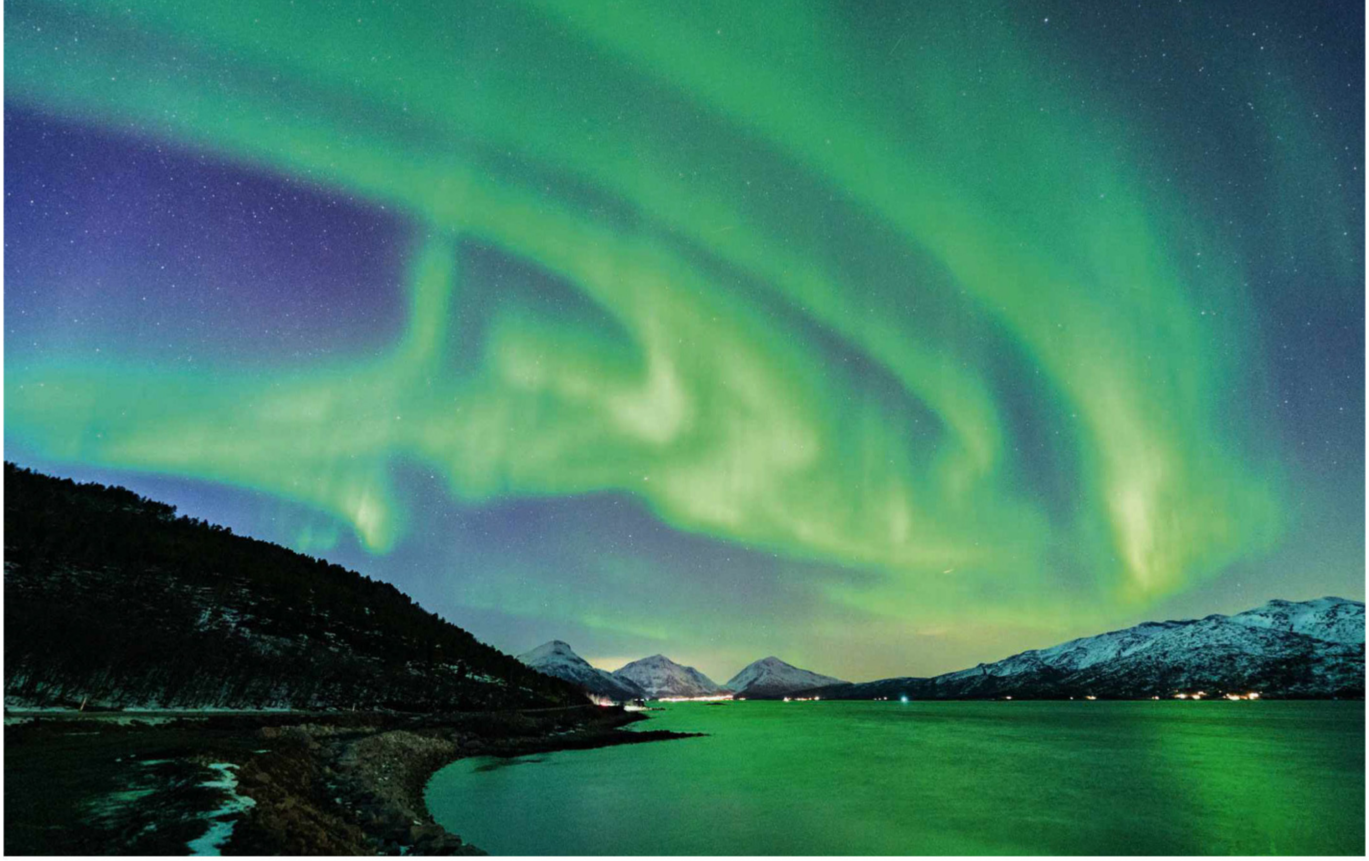
△ The Flaming Star Nebula

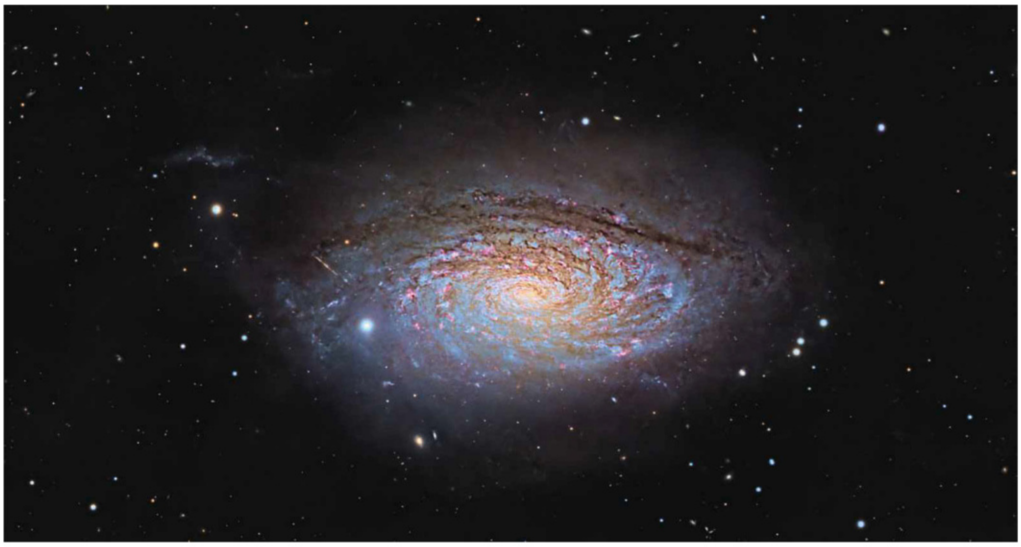
Prabhu, Emirates Astronomical Observatory, Abu Dhabi, UAE, November 2022, April 2023 and October 2023

Prabhu says: "This was a challenging target. I gathered enough broadband and narrowband data to highlight both the hydrogen glow and the blue reflection. Processing was tricky, but I'm happy with how it turned out."

Equipment: ZWO ASI294MM Pro camera, Sky-Watcher Esprit 80 ED refractor, iOptron CEM70G mount, Sky-Watcher AZ-EQ6 mount
Exposure: L 25x 300", 71x 180", R 24x 300", G 24x 300", B 24x 300", total 23h 48'
Software: PixInsight

Prabhu's top tips: "For nebulae, collect enough narrowband and broadband data to ease post-processing. Avoid oversaturating stars in broadband, which can cause haloes or rainbow artefacts. There's no fixed Ha:L:RGB ratio, but 40:40:20 works well. Be patient, experiment and keep trying!"





△ Northern Lights

Chirag Upreti, Lødingen, Norway, 23 March 2025

Chirag says: "As I started to shoot, the aurora quickly expanded to these big, majestic swirls. Aurorae often form interesting patterns around the time of the equinox."

Equipment: Sony A7R III camera, Sony FE 14mm lens, Leofoto Ranger LS-255CEX tripod **Exposure:** ISO 6400 f/2.5, 4" **Software:** Lightroom, Photoshop

△ The Sunflower Galaxy

Ron Brecher, Guelph, Ontario, Canada, 17–28 April 2025

Ron says: "I was able to get 13+ hours on M63, in spite of clouds and the Moon."

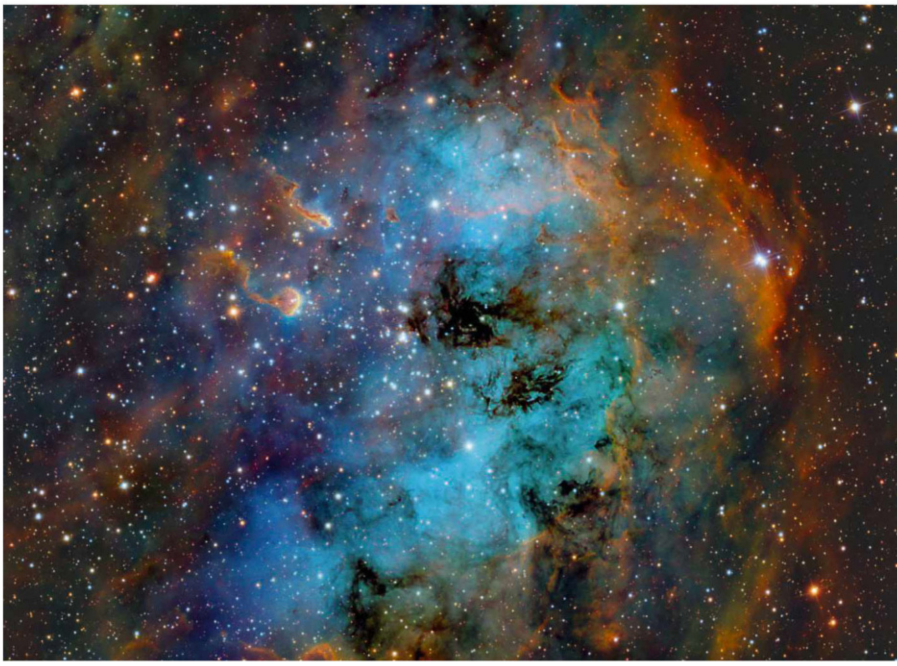
Equipment: QHY600M camera, Celestron EdgeHD 14-inch Schmidt–Cassegrain, Paramount MX mount **Exposure:** R 43x 300", G 37x 300", B 39x 300", Ha 39x 300", 1x 120" **Software:** PixInsight

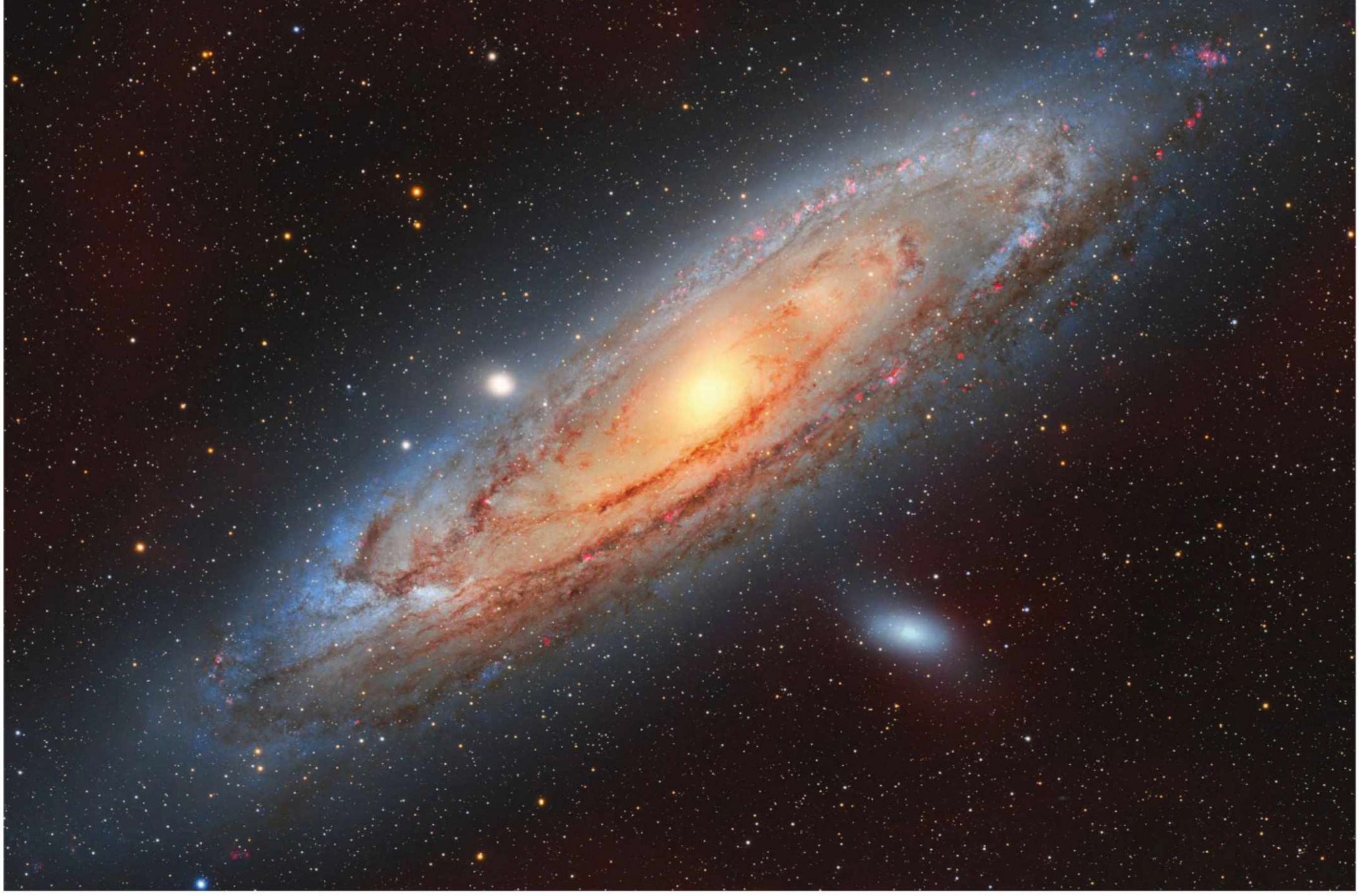
The Tadpole Nebula ▷

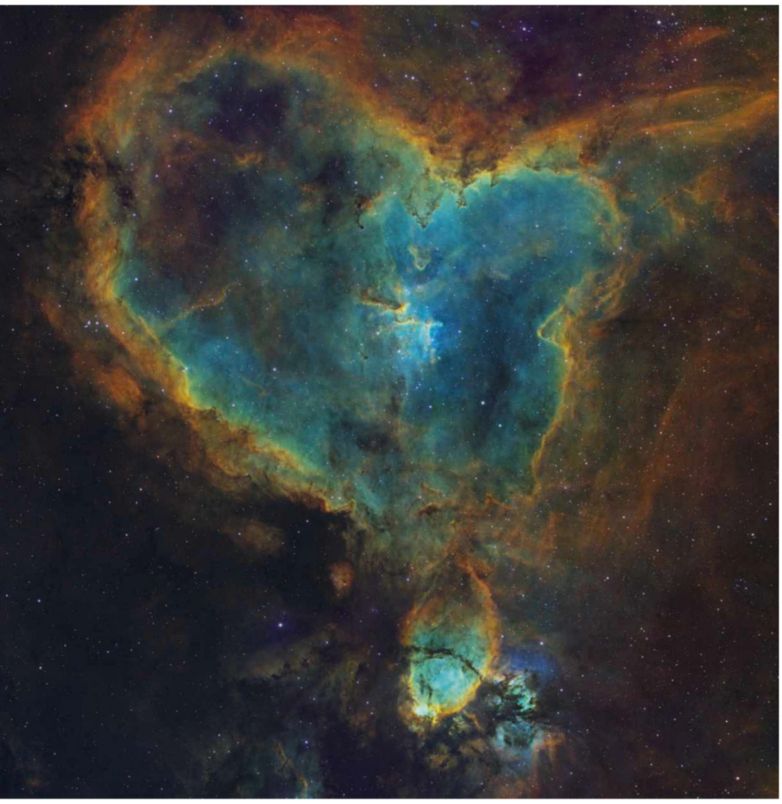
Behyar Bakhshandeh, Descanso, California, USA, 14 October 2023

Behyar says: "It took three nights to collect enough data: I wanted RGB for natural-looking stars, as well as narrowband."

Equipment: FLI ML6303 camera, DSI RC10C Ritchey–Chrétien, Astro-Physics 900GTO mount **Exposure:** RGB 3x 15', Ha 12x 15', SII 19x 15', OIII 19x 15' **Software:** PixInsight, Photoshop







△ The Heart Nebula

Craig Dixon, Scarborough, North Yorkshire, UK, 24 February–11 April 2025

Craig says: “Being circumpolar, the Heart Nebula is a great target for short-focal-length telescopes. Creating a two-panel mosaic allowed me to capture the entire object.”

Equipment: ZWO ASI183MM Pro camera, ZWO FF65 refractor, ZWO AM3 mount
Exposure: R 80x 30”, G 80x 30”, B 79x 30’, Ha 246x 600”, SII 258x 60”, OIII 256x 600”, total 128h 39’ 30” **Software:** PixInsight

△ The Andromeda Galaxy

Adriano Anfuso, Wëntger, Luxembourg, 30 October 2024

Adriano says: “I challenged myself to reveal Andromeda’s faint hydrogen clouds using a one-shot colour camera. I wasn’t sure it would work, but the results exceeded my expectations.”

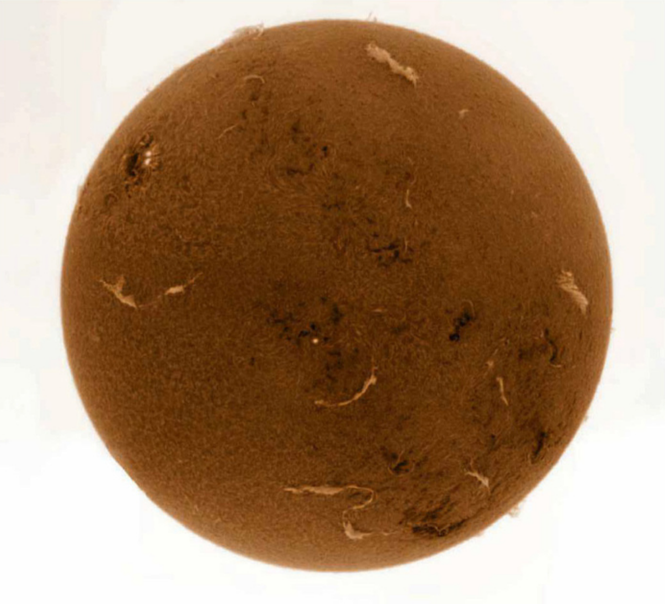
Equipment: ZWO ASI294MC Pro camera, William Optics RedCat 51 refractor, ZWO AM5 mount
Exposure: RGB 500x 300”, Ha 154x 300”, total 54h 30’
Software: PixInsight

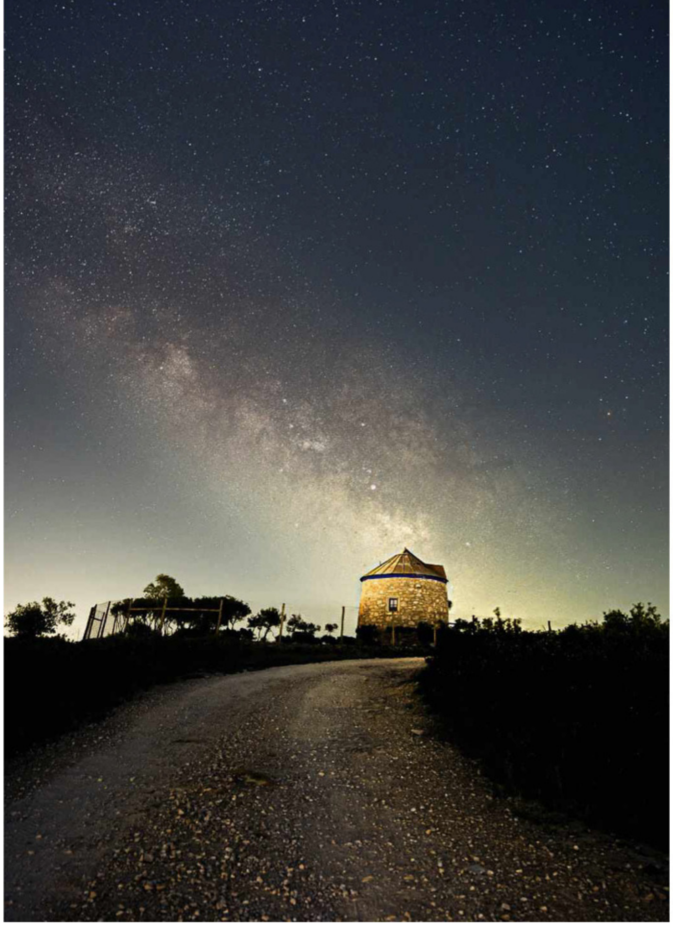
▽ The Sun

Gary Levers, Retford, Nottinghamshire, UK, 30 April 2025

Gary says: “There’s something about seeing the Sun through a hydrogen-alpha telescope. This is a four-panel mosaic that I took at home in Retford.”

Equipment: ZWO ASI120MM camera, Sky-Watcher Heliostar 76Ha telescope, Sky-Watcher EQ5 mount
Exposure: Best 10 per cent of 1,500 frames (per panel)
Software: AutoStakkert!, Image Composite Editor, Affinity Photo



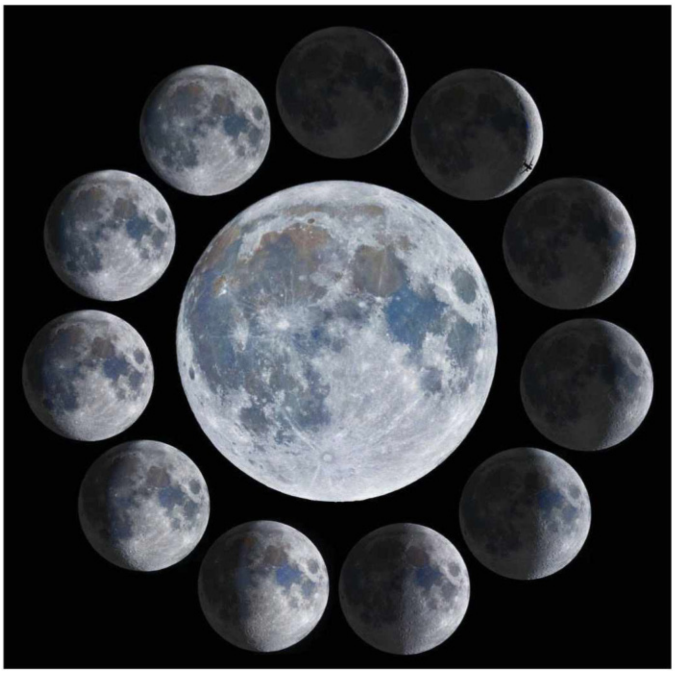


△ The Milky Way

João Miguel Santo, Porto De Mós, Leiria, Portugal, 28 May 2025

João says: "This is the Milky Way visible above one of the Corredoura windmills. The best photo I could get, despite the light pollution from the nearby village."

Equipment: Canon EOS R6 Mk II camera, Laowa 15mm lens, K&F Concept TM2324 tripod **Exposure:** ISO 800 f/2.8, 20x 20" **Software:** Lightroom Classic, Starry Landscape Stacker



△ Lunar phases

Richard Addis, Wallasey, Merseyside, UK, 29 April–12 May 2025

Richard says: "Each of the 12 Moons in this image is a mosaic of between six and 22 panels, each panel consisting of 400–800 frames."

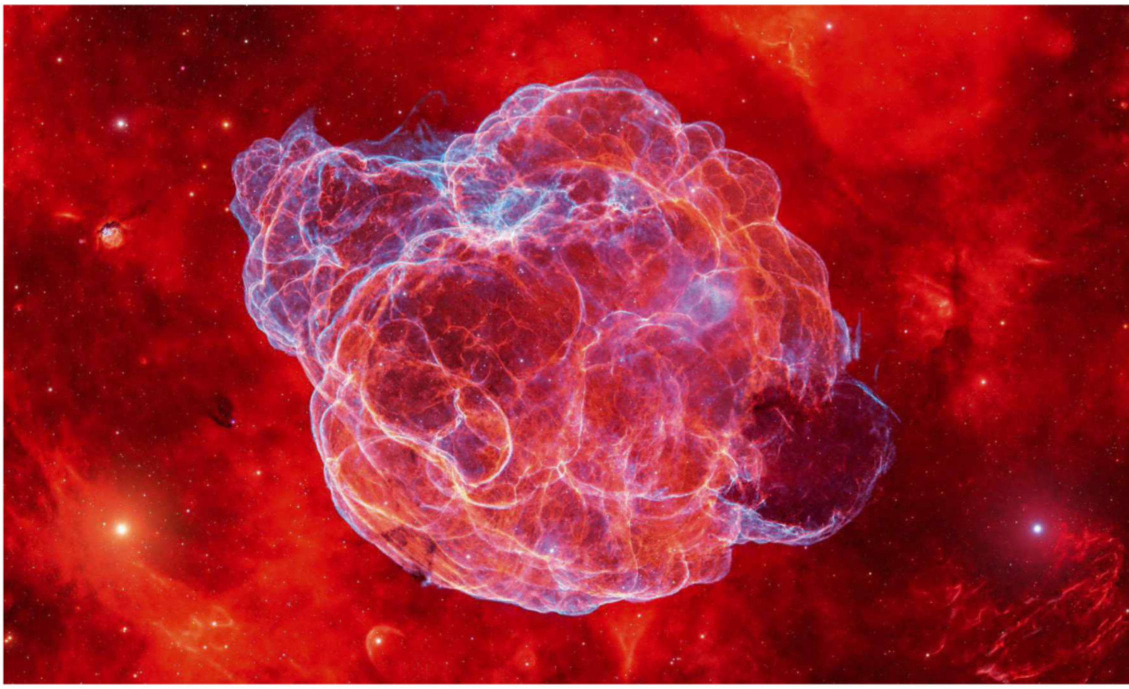
Equipment: ZWO ASI120MC and Nikon D5100 cameras, Celestron NexStar 6SE Schmidt–Cassegrain, Celestron Advanced GT mount **Exposure:** Best 40–80 per cent of 120,000 frames **Software:** AutoStakkert!, Photoshop

The Spaghetti Nebula ▷

Jeffrey Horne, Nashville, Tennessee, USA, February 2023–April 2025

Jeffrey says: "Sh2-240 is one of my favourite night-sky objects, but it's very dim. In order to reveal its faint detail, I collected data over three winters. Mars, visible in the bottom-left, passed through the frame in 2023."

Equipment: ZWO ASI2600 MM camera, Askar FMA180 Pro f/4.5 ED refractor, ZWO AM5 mount **Exposure:** various from 5" to 10', total 569h 4' **Software:** PixInsight, Photoshop



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86

It's built small and lifts big, but how accurate is it? Find out why our reviewer calls the NYX-88 mount a game-changer

NYX 88
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WORDS: JIM OWEN

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- **Mount type** Harmonic drive (EQ/altaz)
- **Load capacity** 14kg; 20kg with counterweight
- **Slew speed** Up to 5° per second
- **Power** 12V DC, GX12 jack
- **Autoguider port** ST4
- **Protocols** ASCOM, INDI, LX200
- **Weight** 5kg; 7kg with tripod
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- **Tel** 020 7935 2580
- **www.** widescreen-centre.co.uk

The NYX-88 from Greece-based Pegasus Astro is a compact harmonic drive mount, named after the Greek goddess of the night. It's the smaller sibling to the NYX-101 and weighs just 5kg, supporting payloads up to 14kg without the need for counterweights, or 20kg with them. We were curious to see if it was as versatile as its specifications suggested.

The NYX-88 arrived in a padded carry bag, with its accessories neatly organised for travel. The head itself felt robust, thanks to its finely machined aluminium alloy construction. We also received the optional Pegasus carbon-fibre tripod for review, which is both lightweight and reassuringly sturdy. Featuring rubber feet and metal spikes, we quickly found it stayed firmly put on any surface.

A printed manual isn't included, so ahead of our first clear night, we downloaded the instructions from the Pegasus Astro website. Attaching the mount head to the tripod was simple, with a retaining screw and tripod spreader providing a secure, stable fit. When fully extended, the tripod legs are noticeably wider than those of similar-sized geared mounts.

Plug in and power up

The ST4 port, USB connection and power switch are all conveniently grouped at the front of the NYX-88, making it less likely you'll knock the power off mid-session. However, with the tripod at full height, we noticed the power cable only just reaches the ground, so you'll need to secure it to the tripod or place a small table beneath the mount. Failing to do so risks the cable dragging, which could compromise guiding accuracy.

Before putting the NYX-88 through its paces, we tested both the supplied USB cable and built-in Wi-Fi, finding each connection to be stable and reliable. Downloading the Pegasus Astro Unity Platform software, we seamlessly linked the mount to a laptop via the manufacturer's control software. We also checked compatibility with external control software, ▶

High precision, low weight

Among the NYX-88's many impressive features is its remarkably light weight. At 5kg, this is a genuine game-changer for any astronomer, regardless of experience.

Night after night, setting up the mount was refreshingly straightforward, making the preparation for clear, dark skies a pleasure rather than a chore. For beginners and first-time users, this simplicity combined with portability will be especially welcome, removing many of the barriers that often discourage newcomers from venturing out under the stars. At the same time, experienced user who regularly travel to dark-sky sites will appreciate just how effortlessly the mount can be packed, transported and quickly deployed, maximising every precious moment of your astronomy time.

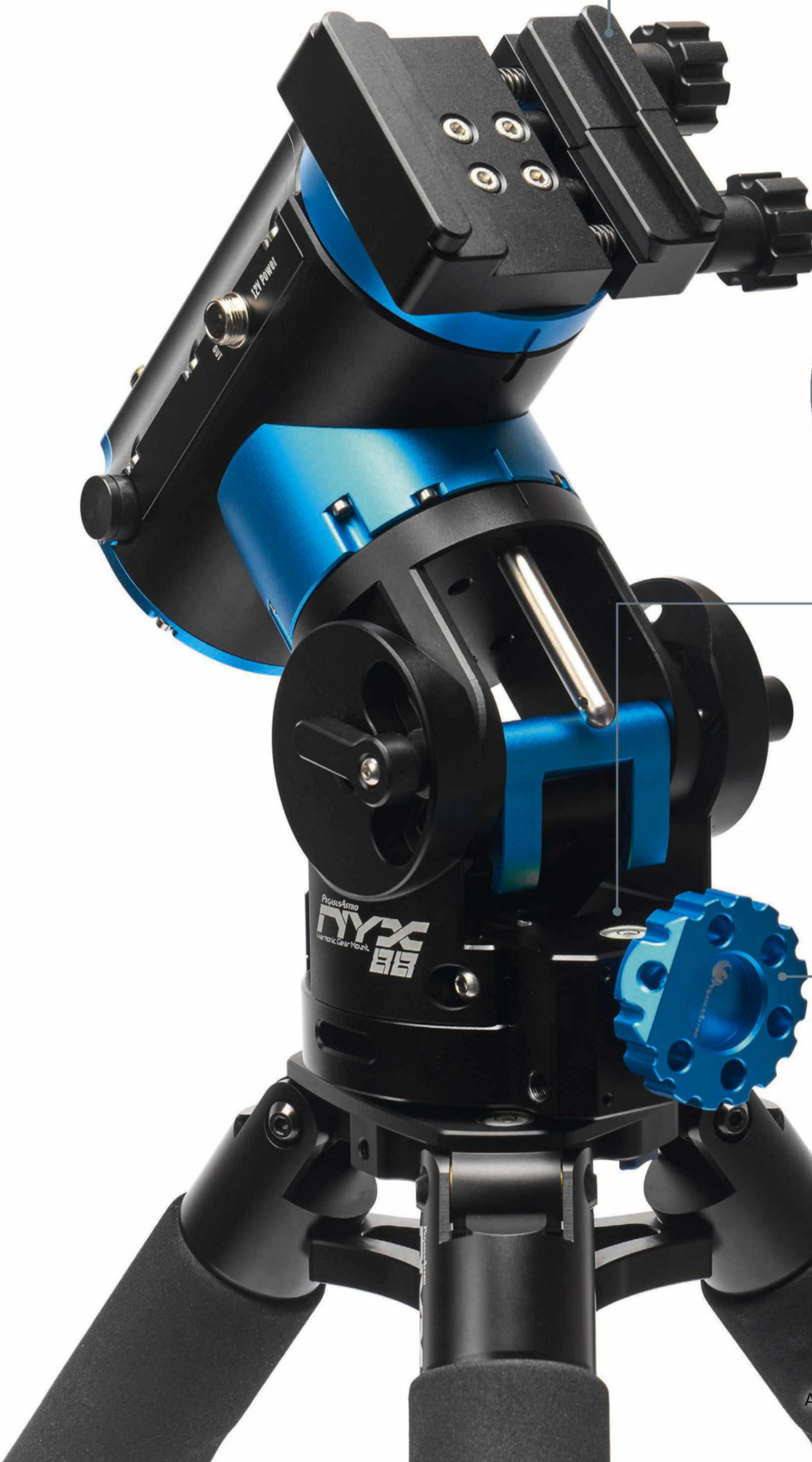
Crucially, this user-friendliness doesn't come at the expense of performance. The NYX-88 consistently delivers sub-arcsecond guiding accuracy and backlash-free tracking, ensuring sharp, stable images whether you're out under pristine rural skies or working with a dedicated imaging rig at home.

For astrophotographers seeking a travel-friendly option that blends precision with reliable performance and intuitive handling, the NYX-88 is an exceptionally capable mount.

ALL PICTURES: @THESHED/PHOTOSTUDIO

Dual saddle

The mount is configured to securely accommodate both Losmandy and Vixen-style dovetail plates, which means it's versatile for a range of visual and imaging telescopes. The retaining bolts are reassuringly large and straightforward to tighten or loosen, even when wearing gloves during colder nights.



Bubble levels

A bubble level is thoughtfully integrated into the mount's design and is positioned to be clearly visible during the setup process. This practical feature makes it easy to achieve a perfectly level platform before starting your stargazing session, ensuring optimal stability and tracking performance right from the start.

Azimuth/ latitude bolts

Polar alignment is made beautifully simple with the inclusion of generously sized adjustment bolts, which are easy to locate and operate even in low-light conditions. This thoughtful design feature greatly enhances usability under dark skies, enabling quick, precise adjustments without unnecessary fumbling.

FIRST LIGHT

Carry case

A compact carry case is included, making it an ideal companion for astronomers who frequently like to travel to dark-sky locations. Designed with both protection and portability in mind, the padding keeps the mount safe and secure during transit, shielding it from bumps and scratches on the road.

Screw-in power cable

We were especially impressed by the screw-in power lead, a simple yet well-considered feature that effectively prevents accidental disconnections during a session. This added design resiliency brings peace of mind when imaging from new locations and busy astronomy club sites, or if you're leaving your equipment to run all night.

► including Astro Photography Toolbox and NINA; both applications recognised and communicated with the mount without issue. While we couldn't test the iOS app due to it awaiting Apple verification at the time of review, we can confirm that Android users can access the app without any problems.

We were fortunate to have clear skies a few days after the mount arrived. Moving the mount plus the tripod into the garden – including carrying them down a couple of steps – was incredibly easy thanks to the total combined weight of 7kg.

We paired the mount with a 350mm f/5 quadruplet refractor and CMOS camera, noting that the saddle bolts were a generous size that kept the telescope securely attached. When we slewed the mount to the zenith, it became evident that a larger scope would clash with the tripod. To avoid this happening for longer focal lengths, an optional pier extension is available.

Hassle-free alignment

Since the mount does not include a polar scope, you will need to use software for polar alignment. We used SharpCap and discovered that accurate alignment was easy to achieve. We slewed confidently to a selection of targets, where the Go-To system demonstrated excellent accuracy and consistently placed each object within the field of view. After a brief tour, we settled on Bode's Galaxy, M81, and the Cigar Galaxy, M82, framing both galaxies perfectly.

PHD2 calibration was swift and straightforward, with no sign of backlash to impede the mount's guiding accuracy. Our captures of this iconic galactic pair were particularly impressive, with crisp detail evident throughout.

We ran three-minute and five-minute exposures; despite poor seeing, our PHD2 guiding corrections consistently settled around 0.6 to 0.7 arcseconds, which ensured sharp, detailed results.

When the next clear spell arrived, we set our sights on a more demanding target: 10-minute exposures on the Iris Nebula, which was positioned to the northeast and glowing faintly within the city's light pollution. Despite the less-than-ideal conditions, including intermittent high cloud and the ever-present skyglow, the NYX-88's guiding accuracy remained dependably steady, rarely straying beyond one arcsecond.

Throughout our test, the NYX-88 harmonic drive mount consistently impressed with its ease of use and precise tracking.

VERDICT

Assembly	★★★★★
Build & design	★★★★☆
Ease of use	★★★★★
Go-To accuracy	★★★★★
Stability	★★★★★
OVERALL	★★★★★

KIT TO ADD

1. Pegasus Astro half-pier extension

2. Pegasus Astro carbon-fibre tripod

3. Pegasus Astro saddle powerbox (to replace the standard saddle plate)

ALL PICTURES: @THESHED/PHOTOSTUDIO

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Our experts review the latest kit

FIRST LIGHT

ZWO ASI585MM Pro USB 3.0 cooled mono camera

Fast for planets, cooled for deep sky – and all at an affordable price

WORDS: CHRIS GRIMMER

VITAL STATS

- **Price** £699
- **Sensor** 4K Sony IMX585 CMOS
- **Resolution** 3,840 x 2,160
- **Exposure range** 32ms–2,000 seconds
- **Connectivity** USB 3.0
- **Size** 73.5mm x 78mm
- **Weight** 453g
- **Supplier** First Light Optics
- **Email** questions@firstlightoptics.com
- **www.firstlightoptics.com**

ALL PHOTOS: @THESHED/PHOTOSTUDIO

ZWO's original non-cooled mono and colour versions of the ASI585, aimed at planetary imagers, were very well received for their fast frame rates and extremely low noise. So when ZWO announced it was adding the very same Sony STARVIS IMX585 sensor to its deep-sky camera range, complete with two-stage cooling systems, we couldn't wait to get our hands on one to try it.

This 'active cooling' ability allows you to set the temperature of the sensor to as low as 35° below ambient and further reduce noise in what was already a proven low-noise sensor.

Opening the box, we found the ZWO ASI585MM Pro, with familiar bright-red camera body, nestled in a padded zip-up compact case. Included with the camera were three USB cables and a range of adaptors and spacers – a nice touch from ZWO that will help users avoid having to buy extras (often an unforeseen additional expense). Making the most of these, we easily attached our non-ZWO filter wheel and correctly spaced our field flattener.

As with all ZWO's Pro series cameras that feature two-stage cooling, we did note that no power cable was included. You'll therefore need a suitable 12V 2.1mm power supply for the ASI585MM Pro.

After a quick look on the ZWO website, we located the Downloads section and were pleased to see a single driver file covering all their cameras, meaning we didn't need to hunt for the correct one. Adding our own power supply and the supplied USB 3.0 cable, we got the camera connected and it was instantly recognised by our capture software.

Utilising the USB hub on the back of the camera, we connected the filter wheel and motorised focuser, both of which were discovered by our PC instantly and worked flawlessly, proving this to be a great addition. With everything now connected, we started the camera cooling.

Signal vs noise

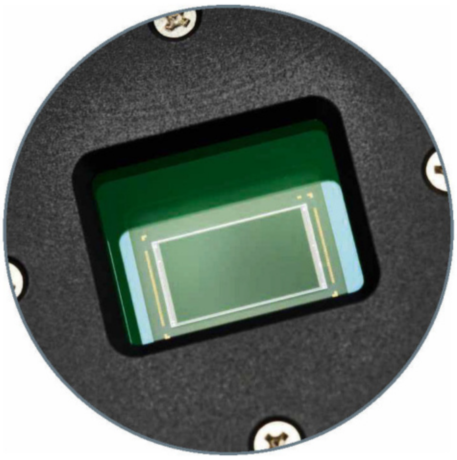
Once it was holding its temperature, we set up to capture some dark frames ranging from 30 seconds to 15 minutes in length, to check how the camera handled noise and other artefacts. Each resulting calibration image was very clean, and we noted that noise was well controlled throughout. The late spring nights meant that true astronomical darkness ▶

Mighty mono sensor

The ZWO ASI585MM Pro is fitted with a mono version of Sony's popular IMX585 sensor. This 1/1.2-inch (11.2mm x 6.3mm) CMOS sensor has 2.9µm pixels and a resolution of 3,840 x 2,160, promising low image noise and zero amp glow. The IMX585 is part of Sony's backlit STARVIS 2 range, suggesting increased light sensitivity and a high signal-to-noise ratio for the camera's price point.

Throughout testing, we indeed observed no amp glow in our images, even when pushing exposures up to 15 minutes with the default Gain setting set to high and a cooler temperature of –10°. Examining each frame also revealed relatively low noise.

Another strength of the ASI585MM Pro is its ability to capture frames at high speed, ensuring it can double as a planetary camera. ZWO advertises a frame-capture speed at full resolution of 47 frames per second, which we achieved with ease during our review. Dropping the capture area to 500 x 500 pixels, we were achieving frame rates exceeding 150 per second, making this a very versatile dual-purpose camera.

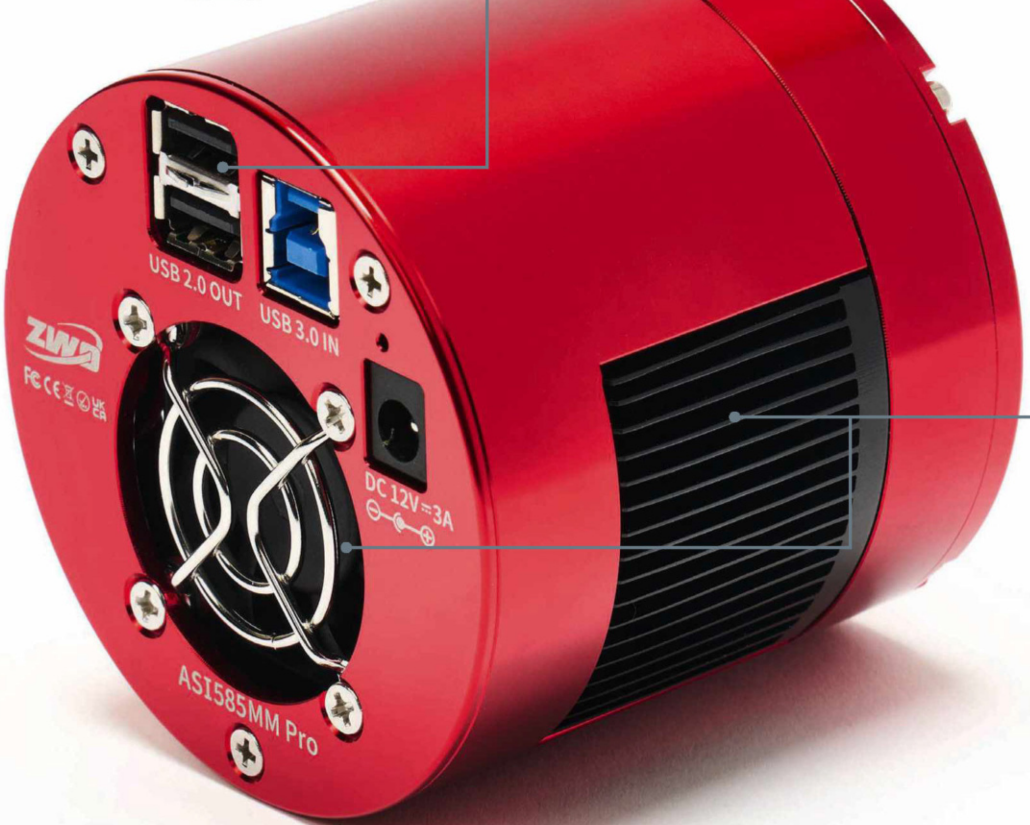


Extension tubes and adaptors

Included with the camera body is an impressive selection of extensions and adaptors that will allow you to connect the ASI585MM to almost any accessory. In the box is an M42 to M48 adaptor, 16.5mm M42 to M48 extension, 21mm M42 extender, M42 to 1.25-inch adaptor, spacers and a 1.25-inch nosepiece.

USB hub

ZWO has included a USB 2.0 hub on the back of the camera, which consists of two USB 2.0 ports that are supplied by the same USB 3.0 cable that controls the camera. This allows for the connection of additional accessories such as filter wheels, guide cameras or focus controllers, reducing cable clutter.



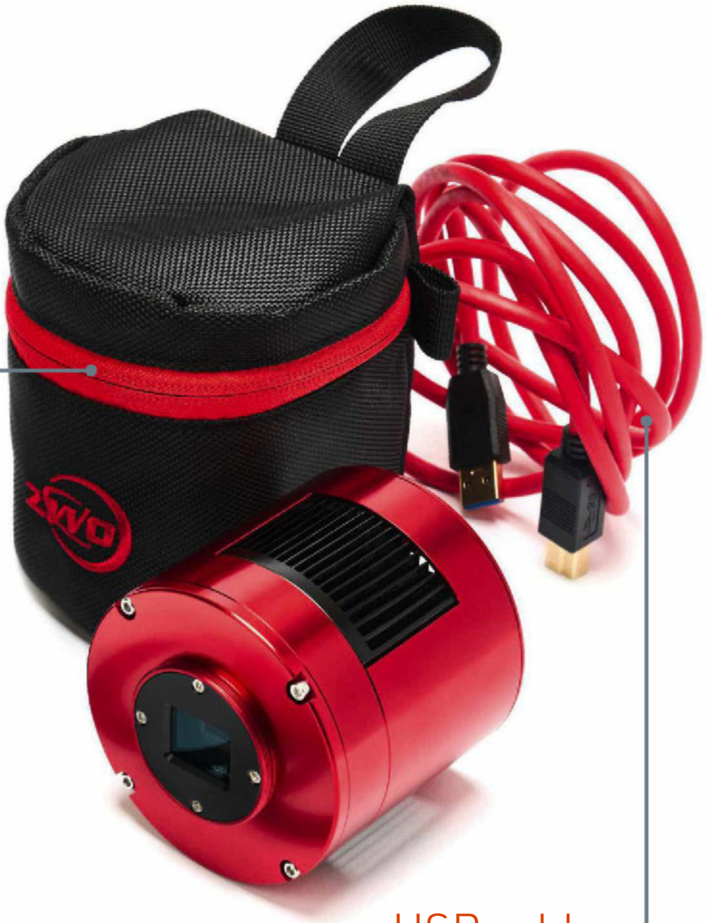
Active cooling

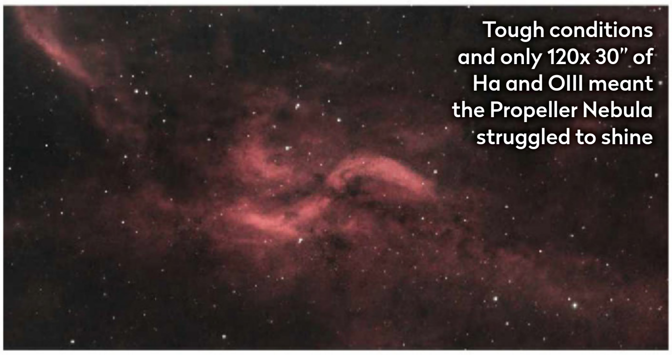
Because the ASI585MM has two-stage cooling, you can achieve a temperature of up to 35°C below ambient with this camera. During use, we easily achieved and maintained –10°C during exposures, while the outside temperature was around 20°C. SGPro reported the cooler systems were only using 54 per cent power.

FIRST LIGHT

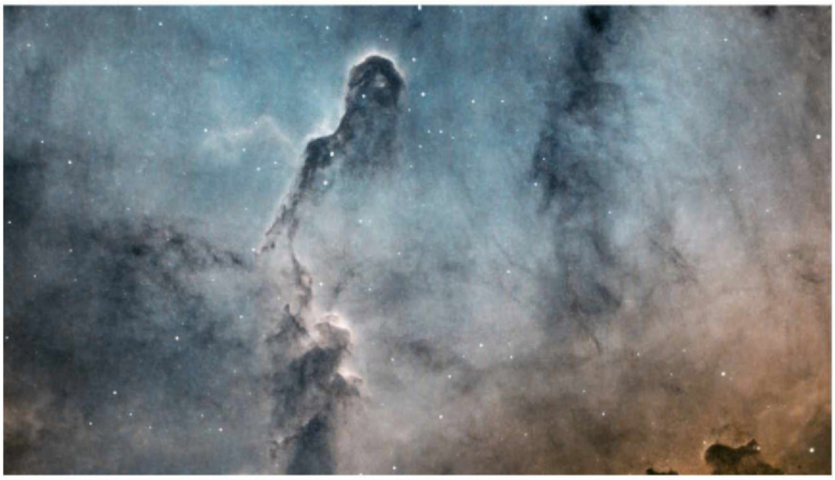
Carry case

The camera is supplied in a well-padded and very sturdy bag, designed in ZWO's characteristic black and red colour scheme. This carry case securely zips up and ensures the camera can be stored securely and safely, free from moisture and dust when it's not in use.





Tough conditions and only 120x 30" of Ha and OIII meant the Propeller Nebula struggled to shine



◀ Getting more data (300x 30") delivered better results with the Elephant's Trunk Nebula. The ZWO was teamed with a WO GT81 refractor for both shots

USB cables

ZWO doesn't scrimp when it comes to accessories, providing three USB cables. The first is a red USB 3.0 cable which controls the camera; at two metres long, it will meet most needs. The second and third are shorter, 0.5-metre right-angle USB 2.0 cables to allow you to connect additional accessories.

▶ was on its way out, but we soon had a clear night to test the ASI585MM. We waited until the Sun had set and Cygnus was rising. Slewing over to the Propeller Nebula, DWB 111, and with a default medium Gain setting selected, we were pleased to see a bright star field even at very short exposures.

With no true darkness available to us, we capped the exposure length at 30 seconds to try to limit the effect of the lighter skies and a reasonably bright waning Moon. Starting with our Ha filter selected, we spent the next couple of hours capturing some hydrogen-alpha data, before reaching for the OIII filter once the Moon had passed.

With our first batch of data collected, we proceeded to get it stacked and processed. Having only captured around 60 minutes on each filter, the Ha data appeared clean. However, once we stretched it in our processing software, it became apparent that more data was needed as fainter areas were grainy and patchy. This was confirmed when a few nights later we processed 150 minutes of Ha data on the Elephant's Trunk Nebula, IC 1396, in Cepheus, which was far cleaner and handled a more extensive stretch.

All in all, the ZWO ASI585MM Pro was a great camera to use and ZWO has once again ensured an incredibly easy setup. For first-time mono users, it's a step up in terms of capture time and processing skill from a basic one-shot colour (OSC) camera. The ASI585MM Pro may be ZWO's lowest-cost active cooled mono camera, but the results returned are anything but budget.

KIT TO ADD

1. ZWO 1.25-inch narrowband filter set

2. ZWO 1.25-inch electronic filter wheel

3. Lynx Astro 21mm power cable

VERDICT

Build & design	★★★★★
Connectivity	★★★★☆
Ease of use	★★★★★
Features	★★★★⯪
Imaging quality	★★★★⯪
OVERALL	★★★★⯪

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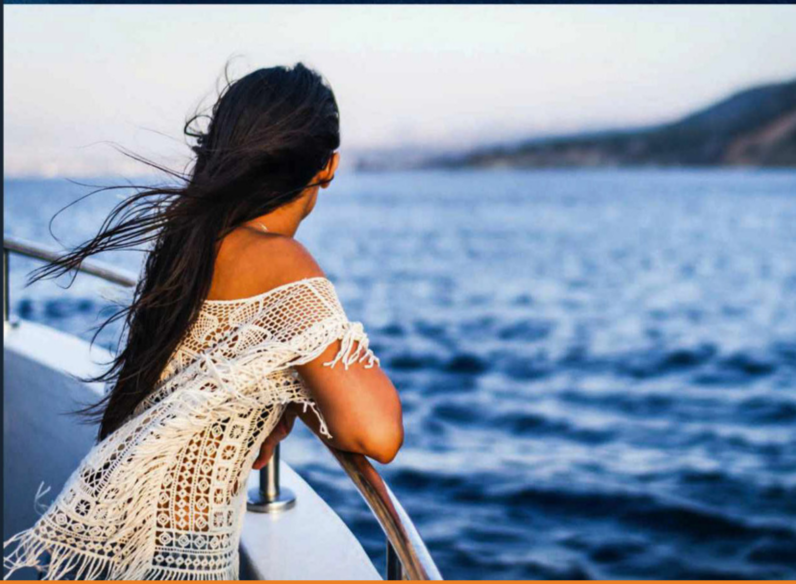

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Charlotte Daniels rounds up the latest astronomical accessories

GEAR

1
2" Duo-Band C2 (SII+OIII) Filter
2" Duo-Band C1 (Ha+OIII) Filter
2
Swan&Edgar
TACHYMETER
3
NORTHERN HEMISPHERE
4
SHUTTLE CARRIER AIRCRAFT
LEGO
NASA
5
BENRO
6
IDC4
4tronix
4 Channel Dew Controller

1 Askar Colour Magic Duo-band filter set

Price £200 • **Supplier** 365Astronomy
www.365astronomy.com

This dual-band 2-inch filter package offers a budget-friendly way to create Hubble Palette images using a colour camera. By condensing three bandwidths into two filters, you can reduce your imaging time and improve contrasts, even in light-polluted skies.

2 World Timer quartz watch

Price £230 • **Supplier** Swan & Edgar
www.swanandedgar.com

This striking stainless-steel timepiece pays homage to space exploration and features an engraved Moon landing motif on the back. The face shows our Earth, Moon and Sun, each displaying separate hour, second and minute counters.

3 Astronomy drinks bottle

Price £35 • **Supplier** Natural History Museum
www.nhmshop.co.uk

Ensure you're ready for a night of stargazing with this 500ml (18 fl oz) insulated drinks bottle. It's suitable for hot and cold liquids, making it an ideal companion for all seasons. The metal cap has a useful carry handle, while the body is adorned with constellations.

4 Lego Shuttle carrier aircraft

Price £199.99 • **Supplier** Lego • **www.lego.com**

One for space enthusiasts who are young at heart! This Lego set comprises over 2,400 pieces and forms the iconic Boeing 747 and NASA Space Shuttle Enterprise. Once assembled, you can deploy and retract the landing gear and open the cargo bay doors. A display stand is included.

5 Benro Mach3 tripod

Price £145• **Supplier** Rother Valley Optics
www.rothervalleyoptics.co.uk

Weighing in at only 2.36kg, this aluminium tripod utilises magnesium castings to ensure it remains lightweight yet sturdy. Featuring twist locks and spiked feet, the three-section design allows it to extend from a height of 41cm to 179cm.

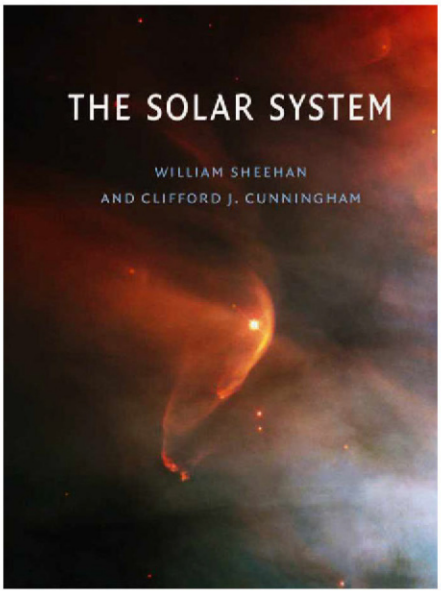
6 4tronix digital dew heater controller

Price £57.95 • **Supplier** Harrison Telescopes
www.harrisontelescopes.co.uk

This four-channel controller is designed to prevent dew from forming on your telescope or camera lens. It's compatible with any 12V dew bands that have RCA phono plugs and it comes with a power lead with a male cigarette-lighter-type plug. Red LEDs indicate each channel's power level.

New astronomy and space titles reviewed

BOOKS



The Solar System

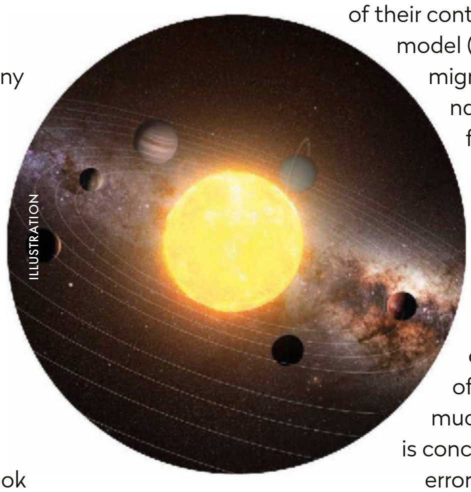
William Sheehan and Clifford J Cunningham
Reaktion
£25 ● HB

There have been many books written about our Solar System. Some are filled with stunning images and detailed ephemera. Others drill down into the physical and chemical processes at play or lay out the history of our discoveries and explorations. This book has elements of all of these, providing an interesting overview of our cosmic neighbourhood for the general reader.

The chapters on Mercury and Venus, Jupiter, Saturn and asteroids, in particular, are very well written. They detail how our knowledge of these bodies progressed from the earliest observations and how our theories were refined as telescopes became more sensitive and we sent spacecraft to fly past, orbit, land and explore. This content is right up to date, including outlines of future missions. It's densely written and comprehensive. Telescope observations detail the name of the astronomer, the location and the size of the telescope. Mission details and discoveries are mostly well documented. There's also a handy table of planetary data at the back. Illustrations and images are plentiful, though there are often long, detailed descriptions of features with no image for reference.

There are some inconsistencies, however. For the general reader, a degree of prior scientific knowledge is assumed and there is little explanation of terms or chemical and physical processes. The writing also gets quite flowery at times. Some chapters begin with a quotation, but sometimes you have to go to the notes at the back of the book to find the attribution. Some scientists' names are mentioned with no context or explanation of their contribution. The Nice model (of planetary migration) is namechecked in the first chapter, but not explained until the final chapter.

The chapter on the Sun is short on scientific details. Mars is the most observed and visited of all the planets, but much of this chapter is concerned with the erroneous observations of canals, who saw them, who didn't, what telescopes they were using and when. Many later space missions are thus relegated to a mere list of mission names and dates. But overall, this is a good, general companion to our corner of the cosmos. ★★★☆☆



ILLUSTRATION

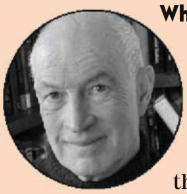
***The Solar System* gives an illustrated rundown of the bodies in our corner of the cosmos**

SCIEPRO/GETTY

***Jenny Winder** is a science and astronomy writer and broadcaster*

Interview with the author

William Sheehan



What Solar System body would you love to visit?

From a practical point of view, it would have to be the Moon, since it's the only body within a few days' travel time. Practical considerations aside, Saturn, with its majestic globe, aurorae, complex rings and unrivalled retinue of satellites (whose number has risen by 128 since *The Solar System* went to press, now standing at 274). A stunningly beautiful planet.

Which bodies are overdue a mission?

Uranus would be good for an extended orbiter mission. It's an icy giant like Neptune but, unlike the other planets, rotates on an axis almost parallel to its orbital plane, so it rolls end over end around its orbit. It has complex seasons during its 84-year-long orbit around the Sun, 13 rings and 28 satellites. We'd really like to know more about it, especially how it came to have that peculiar axial tilt.

Beyond Earth, could life exist elsewhere in the Solar System?

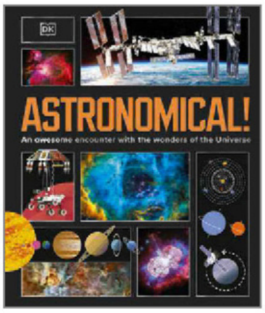
Though intelligent life can be ruled out, there may have been life on Mars during its early history, when it was warmer and wetter. We may find out, if we can get samples back from the surface. Jupiter's moon Europa, which has an ocean beneath its icy crust, or Saturn's moon Enceladus, which ejects plumes of water vapour and organic materials from its subsurface ocean, are distinct possibilities for microbial life. Even Venus – where phosphine gas, possibly due to microbes floating in the clouds, has been found by space probes – is a remote possibility.

***William Sheehan** is an astronomy historian and author*

Astronomical!

GREAT FOR KIDS

Sophie Allan, Josh Barker and Isabel Thomas
DK
£19.99 ● HB



When it comes to children's guides to the fast-changing subject of astronomy, publications need to be thoroughly up to date to reflect not only the most recent research but also the latest images and pictures. This new offering from DK certainly succeeds. Every page is crammed full of wonderful photographs augmented by easy-to-understand graphics. The emphasis is on pictures; what text there is offers brief introductions and summaries of the relevant astronomy.

The first half of the book takes us through the Solar System from Mercury to Pluto via the other planets (not forgetting our own), and smaller objects such as asteroid Ceres. It covers relevant space missions from the Parker Solar Probe to New Horizons' rendezvous with Pluto. Then we're presented with information about stars at different stages in their evolution, from their birth in stellar nurseries, such as the Pillars of Creation, to supernovae remnants such as the Crab Nebula.

It's always interesting to see what book publishers perceive the most important or engaging aspects of astronomy to be. Perhaps in the past we would have opened similar guides to the Universe and found images of distant galaxies taken by the Hubble Space Telescope, but *Astronomical!* puts the focus on planets and stars, with only a few pages dedicated to examining our Milky Way and other galaxies.

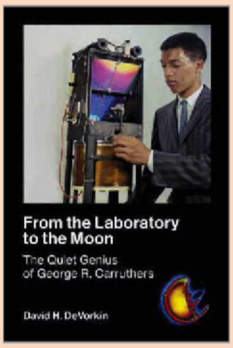
DK has a huge amount of experience and a great track record in presenting science and technology to children in appealing books, and clearly understands the power of the 'awesome', not just in space itself but also in the relevant human technologies that allow us to learn more about the Universe. So it's great that this book has detailed spreads on the Apollo missions, the James Webb Space Telescope and the asteroid lander OSIRIS-REx. But, as with so much of the media, there is a tendency to credit only NASA by name and anonymise other space agencies. For example, the Japanese Hayabusa mission was the first one to return a sample from an asteroid, but this is only mentioned in passing.

Similarly, the two-page description of the successful Rosetta mission to land on comet 67P/Churyumov–Gerasimenko is a great summary of this incredible technological feat, but nowhere are we told that the European Space Agency (ESA) was actually responsible for it. But overall, *Astronomical!* is very accessible and highly recommended. ★★★★☆

***Pippa Goldschmidt** is an astronomy and science writer*

From the Laboratory to the Moon

David H DeVorkin
MIT Press
£72 ● PB


From the Laboratory to the Moon
The Quiet Genius of George R. Carruthers
David H. DeVorkin

During the six hours that Apollo 16's lunar landing was delayed, George Carruthers and collaborator Thornton Page had to perform some frantic recalculations. The intended targets for their ultraviolet electrographic camera, the first astronomical telescope to observe from another planetary body, had shifted due to the Moon's rotation. Astronaut John Young required revised altitude and azimuth settings for the planned observations – and fast.

The man at the centre of this drama, George R Carruthers, stood out among his peers, not just for his scientific brilliance but for achieving it as an African American during the turbulent decades of the 1950s and '60s. This biography provides a detailed account of his life and career in the context of the world in which he lived. Following the dramatic introduction, there's a chronological account of his work, which included designing instruments that flew on Apollo, Skylab and the Space Shuttle. It also examines his personal life and his desire to inspire others to challenge expectations. Finally, the appendices cover accounts from people he mentored and the conservation of his work, oral history interviews and archival resources.

What comes across is Carruthers' drive to study astronomy at ultraviolet wavelengths, despite the difficulties involved. Working in an era dominated by film rather than digital imaging, his electronic image intensifiers remained useful into the new era of CCD sensors. On his outreach efforts, especially to inspire youngsters, the author really captures his subject's passion to be a visible example to others, no matter what their background.

At times, it reads a little like a textbook, especially sections on the specifics of the instruments he worked on and the results they produced. The level of technical detail may be a little too involved for some readers, although it would particularly appeal to those with an interest in the development of astronomy imaging or ultraviolet observations.

From the Laboratory to the Moon provides some inspiring insights into the perseverance required to succeed in space science. While at times technically dense, it's a compelling biography of an important figure. It's highly recommended for those interested in the human stories behind the space programme and the development of modern astrophotography. ★★★★☆

***Mark Bowyer** is a writer specialising in the history of spaceflight*

Anita Chandran talks to Dr Caroline Freissinet

Q&A WITH AN ASTROBIOLOGIST

Scientists have detected the longest organic molecules on Mars to date, a major leap forward in the search for life on the Red Planet

▲ **Building blocks of life: Curiosity extracted organic molecules up to 12 carbon atoms long from the Martian mudstone**

NASA/JPL-CALTECH/MSSS

What makes your team's discovery on Mars so exciting?
We found large organic molecules composed of 10, 11 and 12 atoms of carbon. These long, chain-shaped molecules – called alkanes – are very fragile. They're much more fragile than the ring-shaped (or 'aromatic') molecules made of carbon that we detected previously. What this shows is that these long-chain molecules can be preserved over geological periods of time.

They were found on rocks that are 3.7 billion years old, which means they were deposited 3.7 billion years ago and preserved until today. This has huge implications for the search for life on Mars, because we believe that, if life ever existed on Mars, it was around the same time that these molecules were deposited.

What do we mean by 'organic' molecules?
We mean molecules composed of carbon and hydrogen. The simplest of these is methane, which is one carbon atom and four hydrogen atoms. We consider organic molecules to be a building block for life, but they can form independently of life. So, the presence of organic molecules does not necessarily mean there is life, but life as we know it would require the presence of organic molecules to develop.

How do these long-chain carbon molecules relate to life on Earth?
We think the long-chain alkanes could come from long-chain fatty acids. We believe that on the surface of Mars these fatty acids assemble themselves into vesicles – capsule-like structures. That's interesting because this might also be how life originated on Earth. We can't yet determine whether the organic molecules are formed from biotic or abiotic processes. It's possible that they come from chemical processes independent of life, or there may be a biological explanation.

What evidence do we need to confirm these molecules have biological origins?
Firstly, we would need to detect more molecules from the same family. We've found molecules with 10, 11 and 12 carbon atoms, but we want to extend this to look for anywhere between eight and 18 carbon molecules. The second thing is that, on Earth, there is a significant difference in the abundance of molecules with even and odd numbers of carbon atoms. With just three types of molecules, it's hard to spot a trend.

How did you make your discovery?
We used Curiosity, the rover that's been exploring the surface of Mars since 2012, and part of an international collaboration between Europe and the USA. Curiosity drilled for samples in the Gale crater in 2013, a 160km-wide (100-mile) area that was once home to an ancient lake around 3.7 billion years ago. This lake would have housed all the ingredients for life: liquid water, organic molecules, mild temperature and pH, and energy sources. It also had very good potential for preserving molecules because of the type of stone – mudstone – found in this region, which has layers of clay that can trap and essentially protect the organic molecules.

What did you do with the samples?
The region was so interesting that we kept some 'doggy bags' of samples that Curiosity had drilled. Since that time, we've developed some new laboratory methods, which we implemented on the samples a couple of years after the drilling. I found a unique peak on the spectra, corresponding to decane – the alkane with 10 carbon atoms. After that, we did a lot of lab work to confirm our detection and extended the detection to undecane and dodecane (alkanes with 11 and 12 carbon atoms).

A specialist in astrochemistry, **Caroline Freissinet** is a researcher at the French National Centre for Scientific Research

What's next for your team?
There are many potential next steps – which is great! In the short term, the remaining samples we have on Mars can still be tested once we have developed new methods. In the medium term, there is the next mission to Mars, ExoMars, due to launch in 2028. It's due to dig two metres into Mars's surface and would have the capability of distinguishing between the biotic and abiotic origins of the molecules.

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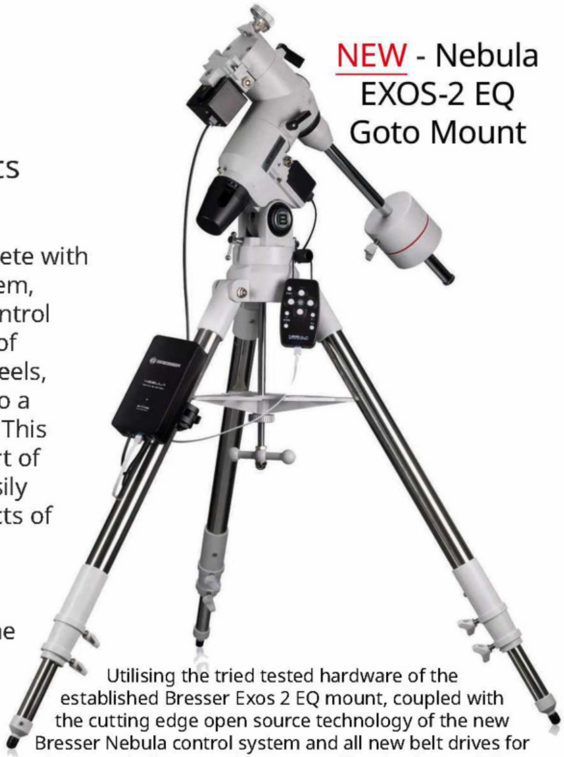

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

This month, see a brilliant pre-dawn conjunction and discover galaxies in faint, forgotten Indus

When to use this chart

1 Aug 00:00 AEST (31 Jul, 14:00 UT)
15 Aug 23:00 AEST (13:00 UT)
31 Aug 22:00 AEST (12:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

AUGUST HIGHLIGHTS

Meetings between Venus and Jupiter, the brightest planets, are always impressive. Jupiter slowly rises in the dawn sky, converging with Venus as it drops towards solar conjunction. Brighter Venus starts the month to Jupiter's upper left, making its closest approach (1°) on the 13th. The pair are 5° apart on 8th–17th, a nice naked-eye or binocular view. They then have notable conjunctions with the Moon, which passes within 5° of Jupiter on the 20th and 7° of Venus the next morning.

STARS AND CONSTELLATIONS

Most stars visible from suburbia are relatively close by, out to around 500 lightyears away. But two bright stars, low in the northern evening sky, present a real contrast: Vega (Alpha Lyrae) is mag. 0.0 and, being 25 lightyears away, is one of the closest stars to the Solar System; Deneb (Alpha Cygni), however, is visually 1.3 magnitudes fainter than Vega, but is 1,700 lightyears distant! One of the largest and most luminous stars known in our Galaxy, Deneb outshines the Sun by 50,000 times!

THE PLANETS

As twilight closes, Mars can be found low in the west below bright Spica. Early evening see Saturn and Neptune rising and transiting around 02:00 (mid-month). August begins with the duo only 1° apart – a good binocular view. Uranus arrives in the early morning, rising around 01:00 mid-month. Dawn brings a real treat: Jupiter and Venus low in the northeast (see above). Around 10–22 August, Mercury makes a brief but poor morning apparition, never leaving the dawn glow.

DEEP-SKY OBJECTS

This month, a trip to the obscure constellation of Indus. A highlight is the impressive double star Theta (θ) Indi (RA 21h 19.8m, dec. –53° 27'). It's ideal for small telescopes, with a yellow naked-eye (mag. +4.5) primary and orange mag. +6.9 companion just 7 arcseconds to the west.

A short stroll 2.6° east-southeast finds NGC 7090 (RA 21h 36.4m, dec. –54° 33'). This 10th-magnitude edge-on spiral galaxy is an obvious 4-arcminutes-long nebulous streak (running southeast–northwest) with a small, almost stellar core. If you find it easy to see, try a more challenging edge-on spiral: NGC 7064 (RA 21h 29.0m, dec. –52° 46'), 1.5° east-northeast of Theta. This 12th-magnitude galaxy is a faint 2-arcminute streak (oriented east–west) showing an even brightness along its length. A 10th- magnitude star is 1.2 arcminutes south of the centre.

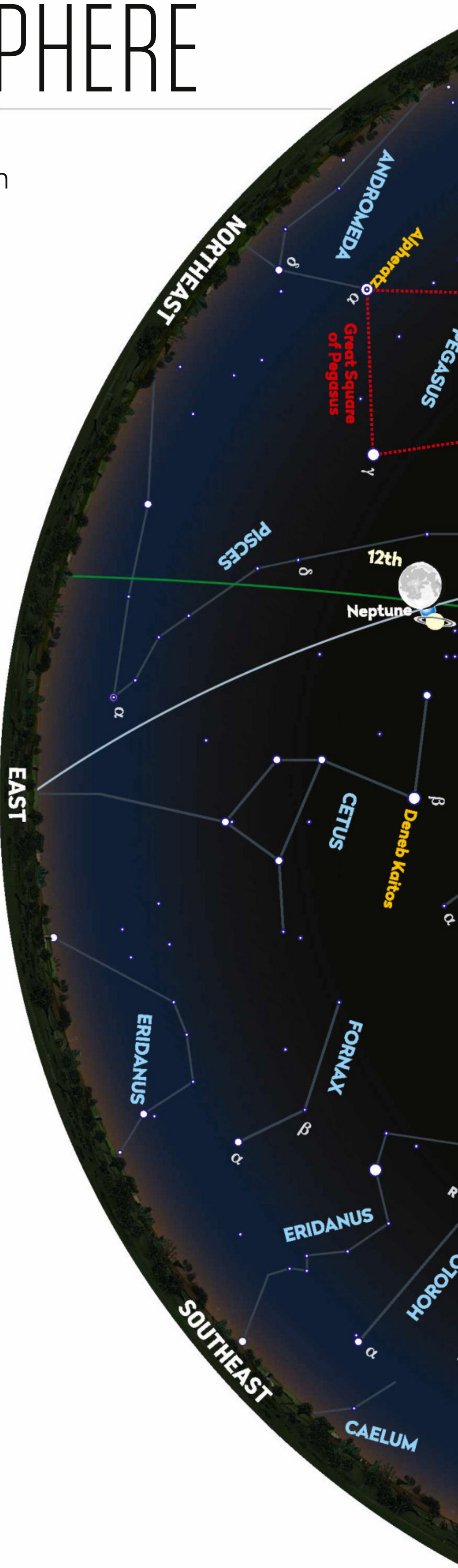
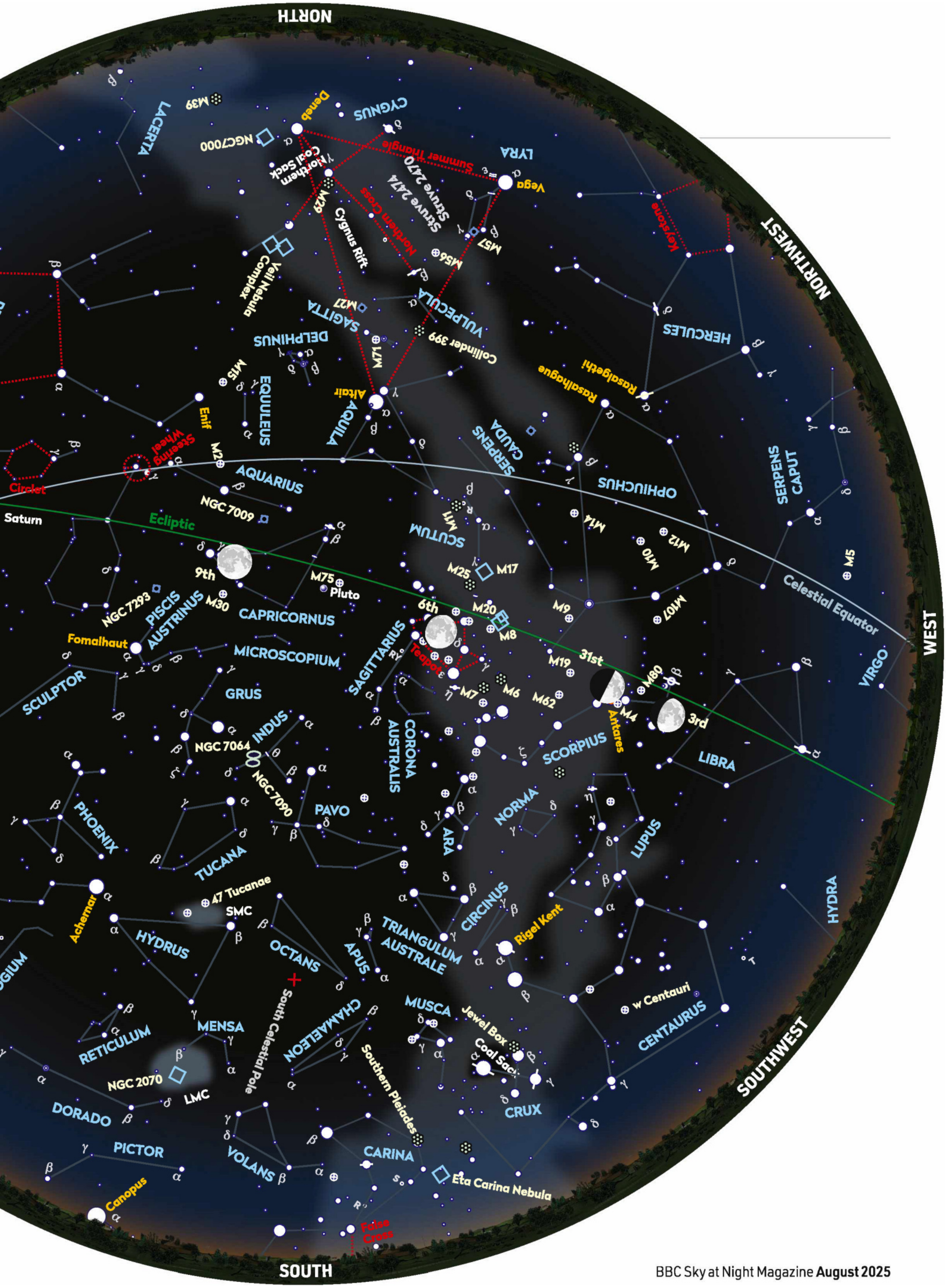


Chart key

GALAXY
OPEN CLUSTER
GLOBULAR CLUSTER
PLANETARY NEBULA
DIFFUSE NEBULOSITY
DOUBLE STAR
VARIABLE STAR
COMET TRACK
ASTEROID TRACK
METEOR RADIANT
QUASAR
PLANET

STAR BRIGHTNESS:
● MAG. 0 & BRIGHTER
● MAG. +1
• MAG. +2
• MAG. +3
· MAG. +4 & FAINTER

CHART: PETE LAWRENCE


NORTH
SOUTH
WEST
NORTHWEST
SOUTHWEST
CYGNUS
Deneb
M39
LACERTA
NGC7000
Northern Coal Sack
Summer Triangle
LYRA
Vega
M29
Stuve 2470
Struve 2474
Northern Cross
Cygnus Rift
Veil Nebula Complex
M57
M56
Keystone
HERCULES
Rasalgethi
Rasalhague
VULPECULA
Collinder 399
SAGITTA
M27
M71
DELPHINUS
EQUULEUS
M15
Altair
AQUILA
Enif
Steering Wheel
Circlet
M2
AQUARIUS
SERPENS CAUDA
OPHIUCHUS
SERPENS CAPUT
NGC 7009
Saturn
Ecliptic
SCUTUM
M11
M14
M12
M10
M5
Celestial Equator
9th
M75
Pluto
M25
M17
M20
M8
M9
M107
NGC 7293
PISCIS AUSTRINUS
M30
CAPRICORNUS
6th
Fomalhaut
MICROSCOPIUM
SAGITTARIUS
Teapot
RY
M19
31st
M80
VIRGO
SCULPTOR
GRUS
M7
M6
M62
M4
Antares
3rd
LIBRA
INDUS
NGC 7064
CORONA AUSTRALIS
SCORPIUS
NGC 7090
PHOENIX
PAVO
NORMA
LUPUS
TUCANA
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47 Tucanae
SMC
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TRIANGULUM AUSTRALE
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RETICULUM
CHAMAELEON
Coal Sack
NGC 2070
LMC
CRUX
Southern Pleiades
DORADO
PICTOR
VOLANS
CARINA
Eta Carina Nebula
Canopus
False Cross